A McGRAW-HILL PUBLICATION

TWO DOLLARS

SEPTEMBER 1958

Control ENGINEERING

INSTRUMENTATION AND AUTOMATIC CONTROL SYSTEMS

67 pages on

PROGRAM CONTROL

Equipment

System Design

Applications



SHAFT POSITION TO DIGITAL ENCODERS AND READOUTS



10 bit/turn Shaft Encoder in true Binary...converts shaft position to non-ambiguous true binary data representing input shaft position to 1 part in 1024 for each revolution. Used as input-output devices for true binary digital computers. **No external logic required.**



BCD Shaft Encoder...used where conversion to decimal form with ease is a requirement. All binary lines representing a decimal digit are parallel for ease of recording.



Sine-Cosine Shaft Encoder... presents sine and cosine functions simultaneously and independently. In addition, the limit one, quadrant and polarity data are supplied. Ideal for airborne automatic navigation systems, weapon control and tracking systems.



Digital Readout...performs logical brush selection operation in encoders using "V" scan. Also translates the unambiguous BCD encoder representation into parallel decimal form. Suitable for electric printers, lamp banks, etc.

PLOTTING AND RECORDING EQUIPMENT



X-Y Plotter...for point or continuous plotting, with positive mechanical drive for recording graphic data. Several models available.



Punched Tape Converter...converts the digital information read from punched paper tape into input signals to the Librascope X-Y Plotter.



Punched Card Converter...converts data from IBM punched cards into analog input signals to the Librascope X-Y Plotter.

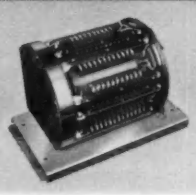


X-Y Decimal Keyboard...consists of a three-decimal bank for each axis with associated plus-minus keys.

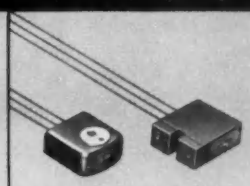
computing components instrumentation & controls

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DIGITAL AND ANALOG COMPUTER COMPONENTS



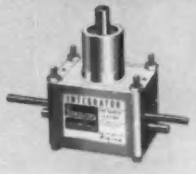
Magnetic Storage Drums...for medium storage applications; capacity 131, 072 non-volatile bits; several speeds; clock frequency 130 kc. Other models available.



Read-Record Heads...for high frequency, non-contact recording applications in magnetic memory systems; high read-back signals. Transistor windings available.



Hollow and Solid Shaft Differentials...designed for high accuracy in additive and subtractive operations...has primary applications to angular velocity, sums and difference, and sequence operations.



Ball-Disc Integrator...for use in totalizing, rate determination, differential analyzers, closed loop servo-element, variable speed drive, temperature correction, etc.

FLOW, VOLUME, AND AREA COMPUTING EQUIPMENT



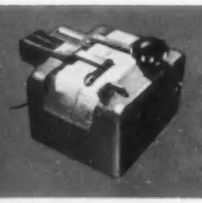
Flow Computer...extracts square root and continuously integrates both differential and static pressures for applications such as orifice measurement of gas.



Linear Integrator...for systems or instruments requiring integration, average computations, direct or remote reading... mounts in strip chart recorders.



Square Root Integrator...designed for the flowmetering industry to provide an economical, continuous, and compact integrator for automatic totalization of liquid flow.



Planimeters...for miniature strip chart recorders for simple integration with variable speed control; 2 models: square root and linear.

COMPUTERS, CONTROLS AND COMPONENTS

Also Process Control Computers, Automatic Data Logging and Control Systems for Industry and Government

Write for additional Information

Librascope's use of the LGP-30 computer simplifies complex design and production problems, and assures computer-engineered quality in meeting delivery schedules.

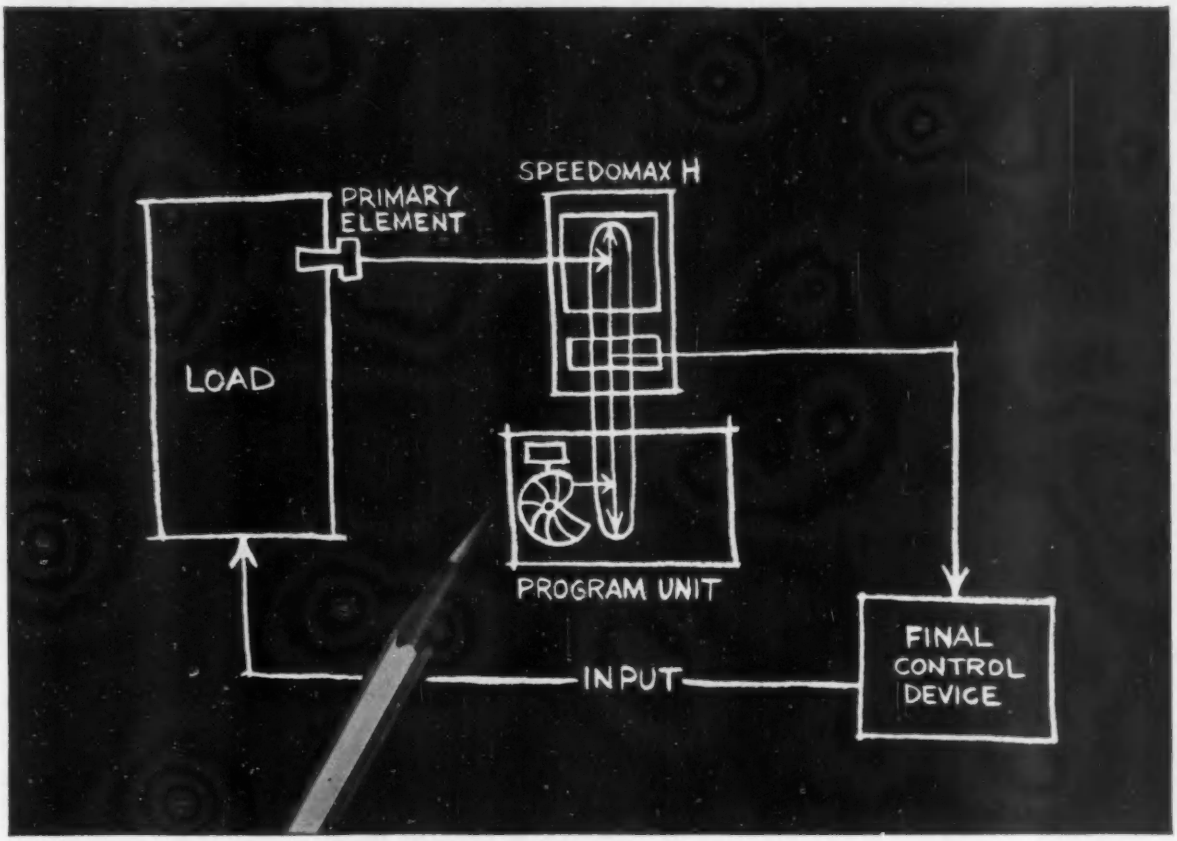


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A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

LIBRASCOPE, INCORPORATED • 808 WESTERN AVENUE • GLENDALE, CALIFORNIA

CIRCLE 1 ON READER-SERVICE CARD



Reproduce your time-temperature cycles exactly with L&N cam-type program control

At the flip of a switch you can heat . . . soak . . . and cool at a preset rate for a preset time with L&N's improved cam type program control! Whether your program is linear or non-linear, this control will continuously regulate input to reproduce *your* cycle . . . again and again.

Heart of the system is the program unit. Essentially it's a motor-operated cam and a control slidewire. The cam is calibrated . . . making it extremely easy to lay out and cut to any time-temperature cycle. Changing a cam to meet a new program takes only a minute. For additional flexibility, the unit has seven standard speeds . . . permitting a multiple number of programs.

Other elements in the control system include a primary element, a Speedomax® recorder and associated control relay, and a final control device. Any change detected by the primary element and measured by the recorder is checked by the program unit, which regulates the final control device to keep the process on cycle.

Also available is a motor-operated front setter type of program control. Recommended for linear programs only, this system offers great flexibility within the range selected.

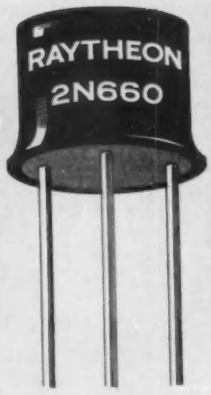
Both types are available for Two-Position or proportioning control . . . will regulate input to electric or fuel-fired furnaces.

Can your process benefit from programmed heating and cooling? If so, it'll pay you to investigate L&N program control. For more information, call your nearest L&N office, or write 4918 Stenton Ave., Philadelphia 44, Pa. Ask for Data Sheet ND46-33(4).

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Instruments — Automatic Controls • Furnaces

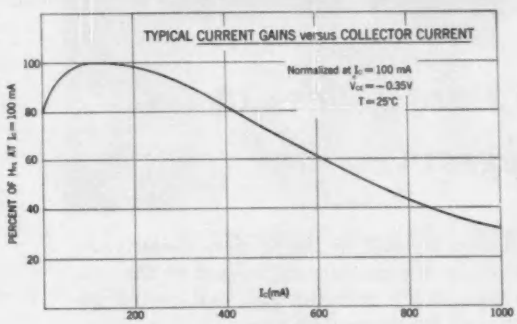
CIRCLE 4 ON READER-SERVICE CARD

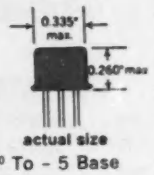
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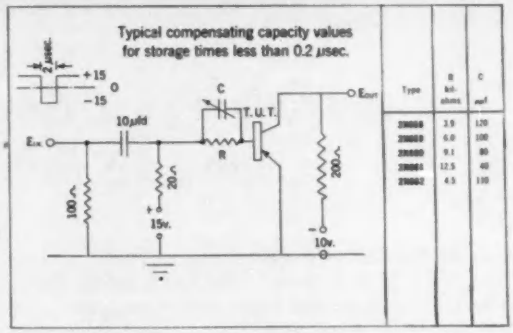


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RELIABLE COMPUTER TRANSISTORS







Type	Punch through Voltage max.	f_{ab} ave. Mc	H_{FE_1} ave. I_B = 1 mA V_{CE} = −0.25v	H_{FE_2} ave. I_B = 10 mA V_{CE} = −0.35v	I_{CO} at −12v μA	r_b' I_C = −1mA ohms	C_{ob} V_{CB} = −6v μμf
2N658	−24	5	50	40	2.5	60	12
2N659	−20	10	70	55	2.5	65	12
2N660	−16	15	90	65	2.5	70	12
2N661	−12	20	120	75	2.5	75	12
2N662	−16	8	30 min.	50	2.5	65	12

Typical values at 25°C unless otherwise indicated

Dissipation Coefficients: In air 0.35°C/mW; Infinite Sink 0.18°C/mW

These new PNP Germanium Computer Transistors made by Raytheon's reliable *fusion-alloy* process add to the already comprehensive line of Raytheon Reliable Computer Transistors which include several in the *Submin* (0.160" high, 0.130" dia.) package. Write for Data Sheets.

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Control ENGINEERING

SEPTEMBER 1958

Published for engineers and technical management men who are responsible for the design, application, and test of instrumentation and automatic control systems

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EQUIPMENT FOR PROGRAMMED CONTROL

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122 **New Developments in Programmers**
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128 **Selecting Punched Tape or Card Equipment for Program Control**
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134 **Selecting a Magnetic Tape System for Program Control**
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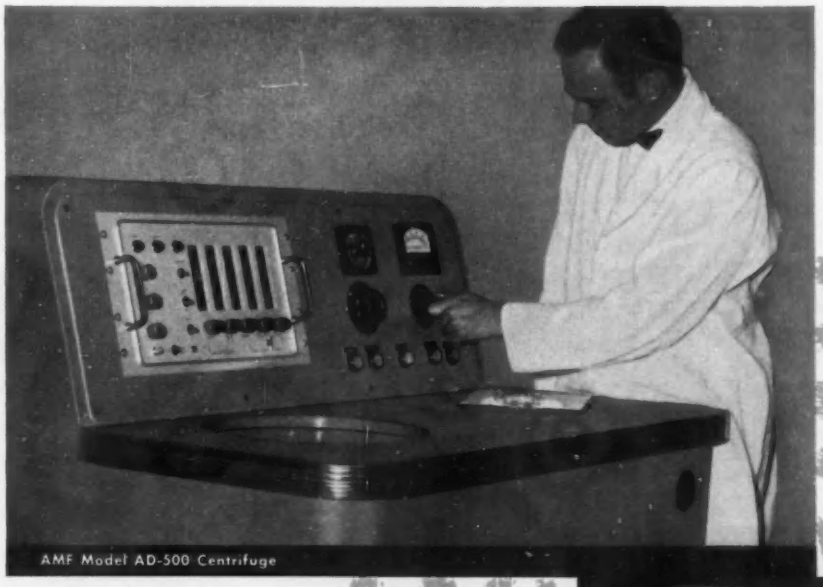
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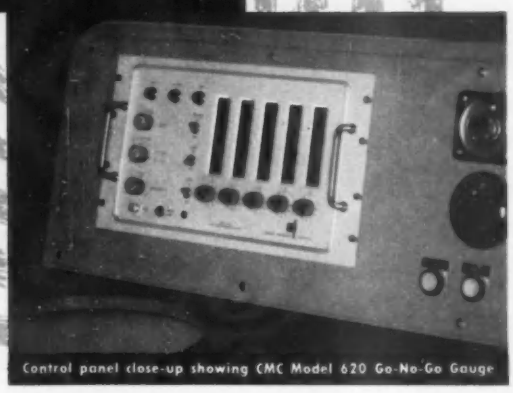
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AMF Model AD-500 Centrifuge

How AMF uses CMC electronic counting equipment



Control panel close-up showing CMC Model 620 Go-No-Go Gauge

For Motor Speed Control

American Machine & Foundry's Model AD-500 is a high speed centrifuge for environmental testing of electronic components. Capable of exerting acceleration forces up to 50,000 G's at 22,000 RPM, the completely automatic Model AD-500 requires a precise speed control system. The system must provide maximum user flexibility and simplicity of operation. AMF chose the CMC Model 620 Go-No-Go Gauge to give their Model AD-500 precise speed control within any pre-selected limits.

Basically, the CMC 620 is a dual preset counter with a built-in time base, which provides output information in the form of relay closures for control purposes. Before the Model AD-500 is started, upper and lower RPM limits are set on the control knobs of the dual preset decade units. The test is then begun. As the centrifuge rotates, a tachometer generator provides the input information to the Model 620 which reads directly in RPM. If the motor speed falls within the pre-selected limits, the green "IN LIMITS" lamp lights. Above or below limits, the red "HIGH" or "LOW" lamp lights and the associated relay closure takes place, de-energizing or re-energizing the motor to hold the centrifuge within pre-selected limits.

For complete specifications, description, price and applications information on the CMC Model 620, please address Dept. 089.

OTHER APPLICATIONS...
Include—material flow control, production line testing of electronic instruments and components, pressure or liquid flow regulating-indicating systems, etc.

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Computer-Measurements Corporation

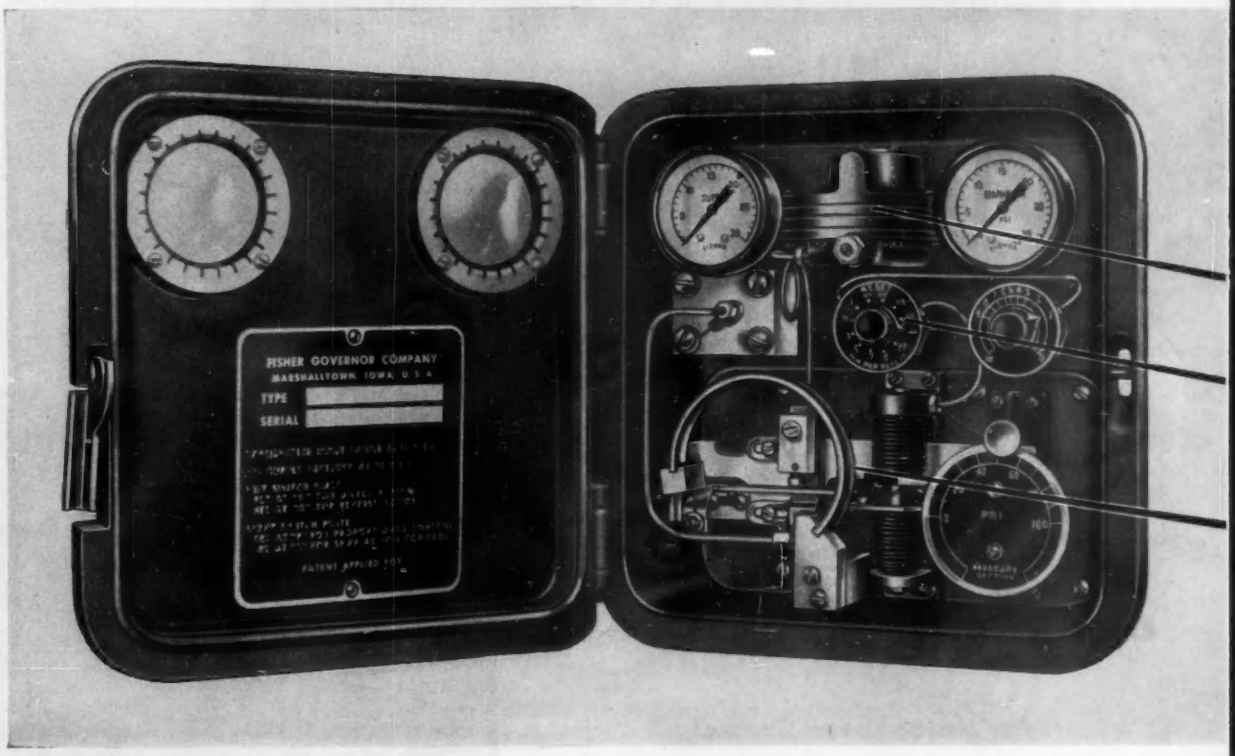
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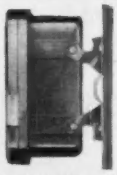
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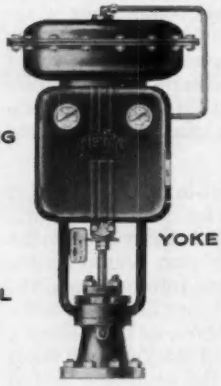
CIRCLE 6 ON READER-SERVICE CARD

Basic Simplicity...faster





SURFACE MOUNTING

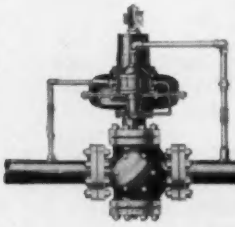


YOKE MOUNTING



FLUSH PANEL MOUNTING

PERFORMANCE DATA	
Test	**Results**
Air or Gas Consumption with 15 psi Output Pressure	Minimum at 10 or 0 Proportional Dial Setting—2 cfh Maximum at 5 Proportional Dial Setting—23 cfh
Resolution Sensitivity	Minimum Change Required in Measured Variable to Produce an Effective Movement of Final Control Element is 0.1% of Bourdon Tube Rating.
Repeatability	Ability of Wizard to Reproduce Its Output Signal for a Given Pressure Setting is 0.5% of Bourdon Tube Rating
Resonant Frequency	Unaffected at Usual Motor and Turbine Speeds.
Temperature Effects	Under Cold Box Test at —20° and Simulated Sun Test from 80° to 212°F Control Pressure Remained Within ±1% of Bourdon Tube Rating.



IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD...

FISHER GOVERNOR COMPANY

response...greater stability

the WIZARD II PRESSURE CONTROLLER

with New and Improved Features

1. **VOLUME RELAY** for faster response to pressure changes.
2. **RESET FEATURE** for greater stability and pin point control, assuring perfect metering, even on multi-stage meter runs.
3. **WIDE RANGE** brass, steel or stainless steel Bourdon tubes cover a range of from 25 to 10,000 psi. Bellows assemblies for low pressure regulation in ranges from 0 to 25 psi.

Again FISHER engineering produces features the industry needs to do a better job

The Wizard II has been designed to specifically meet the demands of modern, complex systems requiring closer control. The Wizard II retains all of the basic simplicity, accuracy and dependability of the Wizard 4100U, plus its own exclusive features.

The new design consists of two sub-assemblies encased in a weather proof die cast aluminum housing which is provided with a ¼" pipe threaded vent for gas service. Either assembly can be removed without disturbing line connections.

The upper assembly consists of two gauges, relay and proportional band adjustment. The lower assembly includes the set point adjustment, proportional bellows, Bourdon tube and nozzle. Each assembly is assembled and calibrated before mounting in the case. The case can be mounted on a flush panel, a wall or on the yoke of the control valve.

Careful and exhaustive tests have conclusively proved that the Wizard II measures up to rigid Fisher standards.

A completely descriptive and illustrated bulletin on the Wizard II is yours for the asking. Write for Bulletin No. D-4150.

The original Wizard I is still available for those applications not requiring volume relay and reset features.

CHANCES ARE IT'S CONTROLLED BY...

FISHER® Controls

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Marshalltown, Iowa / Woodstock, Ontario

MAGNETIC
TAPE
RECORDERS
58
BUYER'S GUIDE

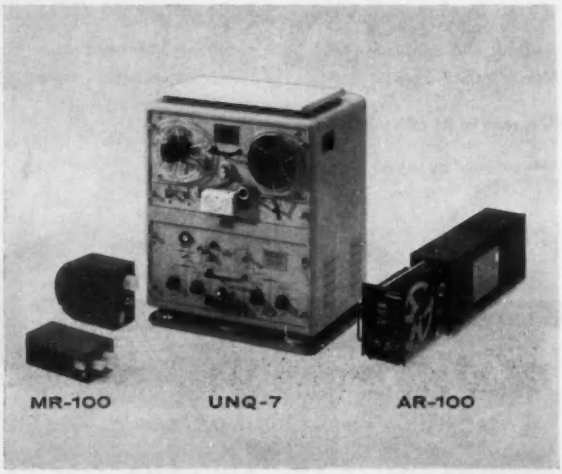
AMPEX
CORPORATION



Magnetic tape recorders for instrumentation and control ..

You get the widest choice, most performance and assured compatibility

Over 95% of all missile prime and subcontractors who are using magnetic tape have chosen Ampex equipment. In today's most rapidly moving technological race, nothing short of the best will do. Missile development pushes at every frontier of engineering knowledge, hence it needs a broad selection of highly adaptable recorders. Tapes must be interchanged among widely separated facilities. So compatibility is imperative. And of vital importance to every user: Ampex offers application engineering and nationwide field service that draw on unparalleled magnetic-tape-recorder experience.



AR-100—AERIAL "LISTENING"
A two-track airborne recorder for data acquisition in the audio-frequency range. Recorder meets the essential requirements of MIL-E-5400 in respect to temperature, vibration, shock and high-altitude conditions. The AR-100 is an example of Ampex's special design work to fill particular military and industrial needs.

Brief physical specifications: 7½ ips tape speed; 7-inch reels; remote and local control; record only, tapes reproduced on other Ampex recorders; 23 pounds total weight including shock mountings.

MR-100—MISSILE RECORDER
A recorder that rides in a missile, recording performance data and playing back in reverse upon reentering range of radio receivers. Playback is automatic or in response to command. The MR-100 withstands shocks up to 75g. Complete two-piece unit occupies less than 1/5th cubic foot. This recorder is applicable to other uses where its ruggedness, compactness and operational sequence are needed.

Brief physical specifications: 60 ips tape speed; precision 5¼-inch reels; ¼-inch tape; two tracks; 4 minutes recording time; tape transport and two-track electronics in cable-connected housings.

UNQ-7—SHIPBOARD RECORDER
A two-track special-purpose recorder handling 7-inch reels with two tracks on quarter-inch tape. It has two speeds, 3¾ and 7½ inches per second. This recorder is shown as another example of Ampex's developments for military purposes.

FR-100A—MOST PRECISE AND VERSATILE

The best recorder for critical data acquisition and processing where low flutter, wide dynamic range and precise amplitudes are required. Typical applications are data telemetry, dynamic tests on engines, components and vehicle structures, and continuous-path machine-tool control. The Ampex FR-100A has superior performance in respect to flutter, low D-C drift, wide frequency response and precise time-base accuracy (with Servo Speed Control). Construction is modular and interchangeable. Numerous standard accessories are available.

Brief physical specifications: Six tape speeds 1⅞ to 60 ips (32-to-1 overall ratio); 10½ or 14-inch maximum reel size; ¼, ½ or 1-inch tape; 2 to 14 tracks; plug-in amplifiers for Direct, FM-carrier, PDM, and NRZ-digital record and reproduce; recorder fits one or more 19-inch rack cabinets.

FR-1100—ADAPTABLE AND ECONOMICAL

A high-accuracy instrumentation recorder recommended for general-purpose laboratory use, spectrum analysis, vibration testing and other comparable applications. The FR-1100's tape mechanism is of a simple open-loop design. Accessibility of components for replacement or service is extremely good. Modular construction makes it readily adaptable to new or special problems. Very wide speed ratios are available in a multirange version.

Brief physical specifications: Four speeds in 2-to-1 steps; eight-speed multirange option provides speed ratios as high as 100 to 1; 10½-inch reels; ¼ or ½-inch tape; 2 to 7 tracks; same plug-in amplifiers as FR-100A; fits 19-inch rack cabinet.

FL-100—CONTINUOUS LOOP

The FL-100 loop recorder provides three different capabilities: 1) cyclic repetition of short tape sections for analysis, 2) continuous time delay of a stream of information and 3) endless monitoring for calamity anticipation. Length of loop is continuously variable between minimum and maximum values, giving cycling times ranging from 0.733 seconds to 8 minutes on various speed and loop-length options.

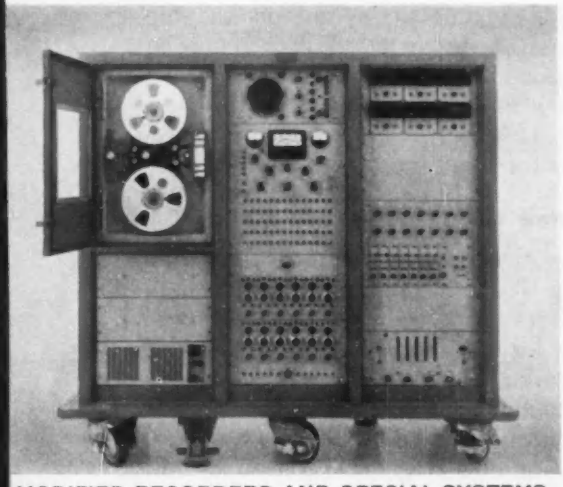
Brief physical specifications: Four speeds in 2-to-1 steps or eight-speed multirange drive with same options as FR-1100; loop lengths from 3′ 8″ minimum to 25, 50 or 75-foot maximums; ¼, ½ or 1-inch tape; 2 to 14 tracks; same plug-in amplifiers.

800B—MOBILE AND AIRBORNE

Newly improved version of the world's most widely used mobile instrumentation tape recorder. The 800B records flight-test data and information acquired in "aerial observation" and also does mobile service on the ground. In compact packaging, the Ampex 800B provides virtually the same recording capabilities as Ampex's larger laboratory-type recorders. In addition, it withstands shock, vibration, high and low ambient temperatures and high-altitude air pressures.

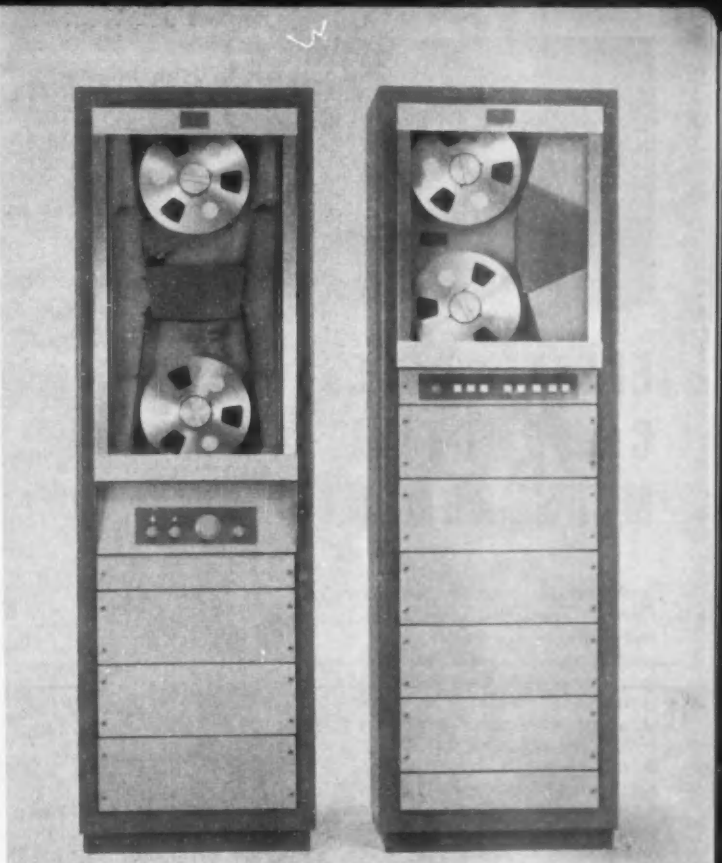
Brief physical specifications: Record only; any of four speeds available; plug-in amplifiers for Direct, FM-carrier or PDM recording; 10½-inch reels; ¼, ½ or 1-inch tape; 2 to 14 tracks; compact cable-connected assemblies fit small available spaces.

the Ampex specialty



MODIFIED RECORDERS AND SPECIAL SYSTEMS

Many regular Ampex models can be furnished with special tape speeds, larger reel sizes, front-access mountings, head switching systems, special performance, system buildups, etc. Ampex has a large modification engineering section thoroughly experienced in this work. The jet-engine test dolly pictured is an example of an Ampex-developed system. It includes an FR-100 recorder, preamplifiers, monitoring scopes and calibration equipment mounted ruggedly for rolling or trucking anywhere in a widespread facility.



FR-300 FR-400

FR-300—HIGH-SPEED DIGITAL

For reading or writing of digital magnetic tapes, the FR-300 offers transfer rates as high as 90,000 alpha-numeric characters per second. It is the first digital tape handler to match the majority of big electronic computers both in speed and in reliability of bit reproduction. Start and stop times are less than 1.5 milliseconds greatly reducing buffer requirements. Ampex furnishes complete digital tape systems including tape handler, magnetic heads, amplifiers and special Ampex Computer Tape.

Brief physical specifications: 150 ips tape speed; 10½-inch reels; ½ or 1-inch tape; 7 to 16 tracks; control of all functions by computer command, also optional local control; read and write electronics will accept and read out digital information in any of a variety of forms; complete equipment fits one 19-inch rack cabinet.

FR-400 and FR-200A—AUXILIARY DIGITAL

For lesser computers and such auxiliary digital equipment as converters, printers, etc., these Ampex digital tape handlers provide a wide range of transfer rates to match any particular need. The Ampex FR-400 uses many of the high-performance components developed for the sensational FR-300, hence is a very heavy-duty tape handler with tape speeds up to 75 inches per second.

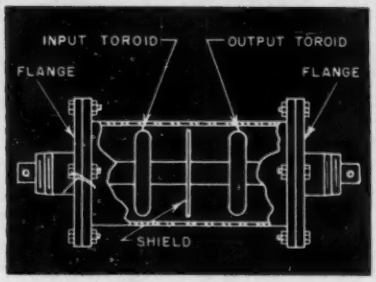
Brief physical specifications: Tape speeds up to 75 ips; 10½″ reels; ½ or 1-inch tapes; 7 to 16 tracks; remote and local controls.



Ampex can send you comprehensive literature and specifications on the various models shown and also a 16-page brochure on principles and applications of magnetic-tape instrumentation. For any of these items, write Dept. HH-58BG.

AMPEX INSTRUMENTATION DIVISION
860 CHARTER STREET · REDWOOD CITY, CALIFORNIA
Phone your Ampex data specialist for personal attention to your recording needs. Offices serve U. S. A. and Canada. Engineering representatives cover the free world.

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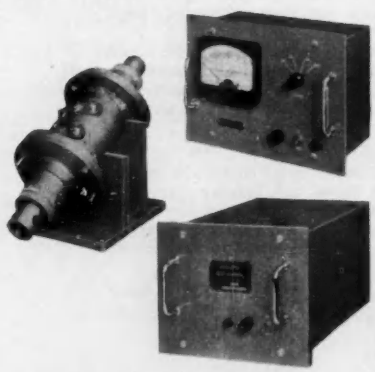


ELECTRODELESS CONDUCTIVITY MEASUREMENTS

A PATENTED electrodeless method for measurement of electrolytic conductivity with instrument readings directly proportional to conductivity over a wide range is available from Industrial Instruments. This new method supplements standard techniques (Wheatstone Bridge circuit and electrodes in solution) and is recommended for conditions where presence of fibers tend to clog conventional conductivity cells, or for abrasive slurries, highly conductive hot solutions, or extremely corrosive solutions.

Input and output toroids are mounted on flow-type cells. Input toroid is connected to a transmitting unit operating in high audio frequency range. Receiving unit is connected to output toroid. The liquid to be measured links the two toroids.

Available to meet explosion-proof requirements and with provisions for automatic or manual temperature compensation. Also available with recording instruments.



For complete details write to . . .

Industrial Instruments Inc.
89 Commerce Road, Cedar Grove, Essex County, N. J.

CIRCLE 9 ON READER-SERVICE CARD

SHOPTALK

Editors scatter east and west

While you're reading this, CONTROL ENGINEERING editors are spread out 5,000 miles to the east of New York and 3,000 miles to the west, searching out international and national control-engineering developments to keep you on top of the field. Bill Vannah—Editor of CtE and Secretary/Treasurer of the American Automatic Control Council—is in Russia, leading an AACC delegation of about 12 top U.S. control engineers on a three-week tour of U.S.S.R. industry and research institutes. Included in the group are CtE consulting editors Dr. Eugene Grabbe of Thompson-Ramo-Wooldridge and Dr. Harry Mergler of Case Institute. You can be sure top-notch coverage of the Russian control scene will be brought to you through the editorial pages of CtE.

At the same time, Associate Editor John Cooney is keeping the roads hot through the far west and on the West Coast, measuring the tenor of control activity and gathering the latest information for CtE readers from this rapidly growing control area.

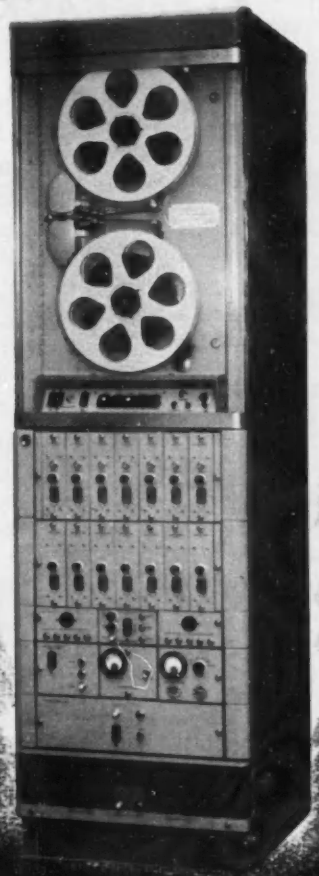
A short lead-time textbook

It takes a long time to author and produce a good textbook, not so long to produce a technical journal. For this reason, technical books and technical journals can serve different but equally important purposes: one for basic reference, the other to keep abreast of the latest developments. Each September the editors of CtE produce an issue designed to have the attributes of both a book and a journal. Nine months before the issue appears they create an integrated outline of what they consider to be the hottest topic in the control engineering field, then obtain as authors the top authorities on each phase of this field. The result is an issue with the timeliness of a monthly magazine and the basic reference value of a book. We hope that this September's coverage of program control will occupy an important spot in your library for some time to come.

Controls must earn their keep

As was mentioned in the August *Shoptalk*, the entire McGraw-Hill Publishing Co. is involved in a campaign to show the latent benefits of modernizing existing facilities. This is not a new theme for CtE: for some time now we've published editorial material showing that the intelligent application of automatic equipment can earn money. Our contribution to the companywide effort will be a special insert in November showing how progressive companies find opportunities to apply automatic equipment; included will be fact-and-figure case histories. This insert will tell you how to find spots for control, how to calculate estimated earnings, and how to prove success. Don't miss it.

90%
of all U.S. long-range missile test flights are recorded on CEC
DataTape



5-752 MAGNETIC TAPE
RECORDER/REPRODUCER SYSTEM

lowest cumulative flutter from 0 cps assured with CEC's DataTape



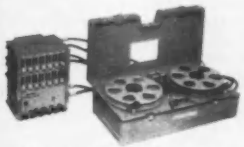
ADJUSTABLE TAPE LOOP ATTACHMENT
Permits fast, inexpensive conversion of the 5-752 into a continuous loop transport for repetitive playback and data analysis.



DIGITAL MAGNETIC-TAPE RECORDER/ REPRODUCER



5-781 MAGNETIC-TAPE RECORDER/ REPRODUCER (continuous loop)



AIRBORNE DATATAPE SYSTEM

Scientists and engineers depend on CEC for equipment of proved versatility . . . precision . . . reliability. They look to CEC for solutions to data-recording problems—and find them in CEC's 5-752 Recorder/ Reproducer System.

The 5-752 delivers instantaneous playback of up to 14 tape tracks with simultaneous recording or reproducing of separate signals. Quickly adaptable to use 1-mil base high-strength Mylar instrumentation tape, allowing 50% more tape footage per reel. Seven different types of plug-in amplifiers record and reproduce in Analog, PDM or FM modes.

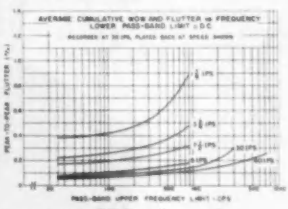
The military and industry alike use the 5-752 in recording telemetered missile data, wind-tunnel testing, jet and rocket engine testing, shock and vibration studies, mobile and stationary structural testing, static and dynamic testing, sound measurements, and medical research.

Two exclusive design advances distinguish the 5-752 as a leader in the field of data recording and reproducing:



ALL-METAL-SURFACE MAGNETIC HEADS
The all-metal-surface of CEC's magnetic heads promotes a self-cleaning action and minimizes head wear. Oxide can't build up on heads to cause drop-outs or loss of high-frequency response.

LOWER FLUTTER EVEN AT LOW TAPE SPEEDS
At tape speeds of 1⅞ and 3¾ ips, cumulative flutter in the 5-752 is about 50% less than the flutter found in other tape equipment. Accompanying chart shows flutter recorded at 30 ips and played back at speeds indicated.



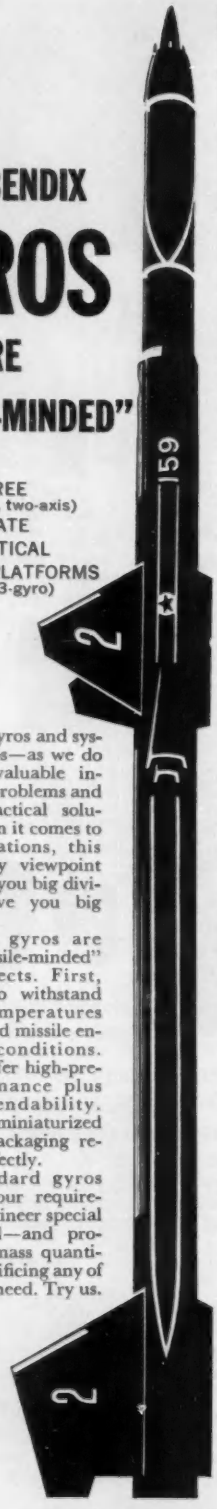
For complete information, contact your nearest CEC sales and service office, or write for Bulletin CEC 1576-X28.

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"MISSILE-MINDED"

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★ RATE
★ VERTICAL
★ STABLE PLATFORMS
(2-gyro, 3-gyro)

Building both gyros and systems using gyros—as we do—provides a valuable insight into gyro problems and their most practical solutions. And, when it comes to missile applications, this unique two-way viewpoint of ours can pay you big dividends, can save you big headaches.

For Bendix gyros are definitely "missile-minded" in three respects. First, they're built to withstand high-range temperatures and other rugged missile environmental conditions. Second, they offer high-precision performance plus extreme dependability. Third, they're miniaturized to fit missile packaging requirements perfectly.

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FEEDBACK

Translation blossoms into a series

To the Editor—

We have just received word from the National Science Foundation that grants have been allowed for translation of three Soviet journals in addition to *Automation and Remote Control*. Under ISA sponsorship, the four translations will make up a Soviet Instrumentation and Control Translation Series. Details of subscription rates and availability dates will be announced just as soon as program details are completed. These are the additional three Soviet journals:

1. *Instruments and Experimental Techniques* (*Pribory i Teknika Eksperimenta*)

Published bi-monthly by the Academy of Sciences. Russian literature states that this journal is "intended for wide circles of scientists, teachers of higher education, engineers and graduate students". It publishes surveys on various fields of physical instruments, original articles on function, construction, methods of application and methods of operation of instruments in various fields of experimental physics. It includes reviews on the improvement of laboratory apparatus and instruments, and outlines procedures for laboratory experiments. It includes data on physics instruments produced by industry, and on new materials used in instrumentation and laboratory practices. Publication was started in Russia about two years ago and there are about 930 pages per year.

2. *Measurement Techniques* (*Izmeritel'naya Tekhnika*)

Published bi-monthly by the Committee on Standards, Measures & Measuring Instruments, attached to the Council of Ministers of U. S. S. R. Publication was started in 1950. There are approximately 800 pages per year. This publication is of particular interest to the National Bureau of Standards and will be of comparable interest to all who are engaged in fundamental measurements.

3. *Industrial Laboratory* (*Zavodskaya Laboratoriya*)

Published monthly by the Ministry of Light Metals. This journal pertains to instrumentation for analytical chemistry, and to physical and mechanical methods of research into materials. It accordingly covers a wide range of instrumentation techniques and methods. It has been published in Russia since 1936. There are approximately 1,500 pages per year.

It is our feeling in ISA that the series will represent a real service to American science and industry. We are indebted to the National Science Foundation for granting the funds that make this program possible.

Nathan Cohn, Chairman
ISA Publications Committee

Congratulations; put us on the list. Ed.

Soviet translation accelerates

To the Editor—

Your February 1958 editorial, "Distribute Russian Translations", has just been brought to my attention. Even though my reaction is rather belated I thought you might be interested in some additional information on the subject and some small corrections.

The journal *Avtomatika i Telemekanika* is now published by Consultants Bureau in a joint project with Massachusetts Institute of Technology and the Instrument Society of America. MIT has obtained National Science Foundation funds for this project, and as a result of the new organization the subscription price has dropped from $185 per year to $30 per year for general subscriptions and $15 per year to libraries of educational institutions and other nonprofit institution libraries.

MIT also publishes, through Pergamon Press, Ltd., translations of three other Russian journals which may be of interest to your readers. These are *Radiotekhnika*, *Radiotekhnika i Elektronika*, and *Electrosviaz*. The annual subscription prices for these translations are, respectively, $30, $45, and $30. MIT has also obtained financial support from the foundation for this project. The journal *Elektrichestvo* mentioned in your editorial has been announced by the Pergamon Institute, which has stated it will publish translations of selected papers. Neither NSF nor MIT is associated with this project. My information from Pergamon is that the annual subscription price for these selected translations will be $56 per year.

The problem which you point out of obtaining the cooperation of all translating organizations with a central clearing-house in order to prevent duplication is certainly still with us,

but a surprising amount of progress has been made toward its solution, and plans are now being laid to push this solution still further.

A government translations clearing-house to supplement the activities of the Special Libraries Association Translations Center has been advocated by the National Science Foundation and the Dept. of Commerce, Office of Technical Services, which have worked together and with other agencies in the development of these plans. The Dept. of Commerce is requesting funds to establish this center in its fiscal year 1959 budget which is presently being reviewed by the Congress. The "bottleneck of secrecy" has been largely if not entirely broken wherever it could be without endangering national security. All agencies which translate, including the military and intelligence agencies, have promised to extend maximum cooperation to any clearing-house established. Some of this information is getting to the public now, and we expect that the rest will be within the next few months, when distribution plans will, hopefully, have been drawn up.

Ralph E. O'Dette
Program Director for Foreign Science Information
National Science Foundation, Washington, D. C.

National Science Foundation provides financial support, MIT manages the effort, Consultants Bureau translates AiT, and ISA markets the translation. Publication begins with Vol XVII, January '57. This issue and the February issue are ready for distribution now. All 12 of the 1957 issues should be distributed by the end of '58. Forward subscriptions for the translation to ISA, 313 Sixth Ave., Pittsburgh 22, Pa. Ed.

On professional relations with Soviets

To the Editor—

This is in regard to the matter of professional relations with U. S. S. R. scientists, particularly those associated with the Institute of Automatics and Telemechanics in Moscow. Many of us in the automatic control field are becoming involved in such relations and I am sure that many, such as myself, are a little confused in regard to the "rules of the game".

I have received correspondence from a number of members of this Soviet Institute in regard to interchange of technical publications. A considerable volume of papers and books have been received; except for a few with English translations, I unfortunately cannot read them although I

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have obtained interpretations of the titles and tables of contents. In return, I have sent some reprints of technical papers of my own and my colleagues to them.

Three specific problems have arisen in regard to the above for which you may be able to offer solutions:

1. First, there is the matter of security and Dept. of Commerce regulations. It has apparently now been clarified, at least until the rules are changed, that regularly published material may be mailed to the U. S. S. R. with no export license required. However, in the interchange of papers, occasions arise for comments of a technical nature. One Soviet control scientist has asked me for some specific comments in regard to a recent paper of his sent to me in the form of an English translation. A strict interpretation of the U. S. Dept. of Commerce regulations (CFR, Title 22, Part 75) would prohibit such an exchange of technical information that was not specifically in published form. It would appear that an export license would be required before engaging in such an exchange, a procedure that suggests red tape in which no individual would care to become involved. On the other hand, professional courtesy requires some answer to such requests.

Our Washington News Bureau advises that the Office of Technical Services of the Dept. of Commerce has the responsibility for advising private citizens on the propriety and security aspects of exchanges and also of disseminating Soviet scientific and technical papers, for which purpose it received a half-million-dollar appropriation from Congress.

There is no official regulation of private correspondence between citizens of the U. S. and citizens of the U. S. S. R. First-class mail to the U. S. S. R. no longer is censored and the requirement that it carry special symbols indicating the contents has been dropped. Thus, comments in writing on a Soviet scientific paper by an American scientist can be sent to U. S. S. R. without violating any regulations (assuming the comments are not on classified topics). Ed.

2. It has been suggested by the Soviet engineers that we exchange books as well as papers. I have one specific request as of now for Otto Smith's recent McGraw-Hill book, *Feedback Control Systems*. Some sort of coordination of such book-exchange activity seems desirable rather than a conducting of it on an

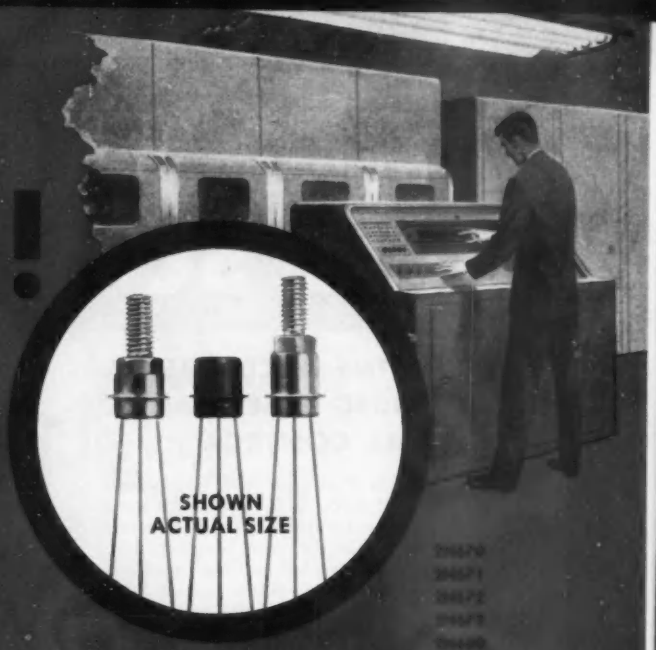
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2N670	40	2	0.3	0.65
2N671	40	2	1	0.65
2N672	25	2	0.3	1
2N673	20	2	1	1
2N600	20	0.4	0.75 (1.0 peak)	5 MIN.
2N601	20	0.4	0.75 (1.0 peak)	12 MIN.

Announcing Philco's newest family of PNP germanium alloy junction, high current switching transistors specifically designed for industrial relay driving and pulse amplifier applications and for computer core driver circuits. These transistors feature current ratings to 2 amps, voltage ratings to 40v and alpha cutoff frequencies to 12 mc.

- The 2N670 and 2N671 with 2 amps max. collector current, continuous max. power dissipation up to 1 watt, plus controlled current gain, input drive voltage and saturation resistance at 1 amp are particularly useful in "ON-OFF" industrial control systems.
- Types 2N672 and 2N673 featuring a maximum 0.5 microsecond, one-half ampere rise time are intended for pulse amplifier and tape and drum writer applications.
- The 2N600 and the 2N601 are high speed power switches specially designed for core driving applications. They feature power dissipation up to 1 watt, current ratings of 400 ma and controlled minimum alpha cutoff frequencies of 5 and 12 mcs.

Each of these transistors is housed in Philco's exclusive cold welded, all-copper, hermetically sealed package on JETEC TO-9 base. Positive heat sinking is obtained by tieing a transistor element to the copper case. Types 2N671, 2N673, 2N600 and 2N601 are designed with threaded stud and hexagonal shoulder assembly. All of these transistors are available in production quantities.

Make Philco your prime source for all transistor information and prices. Write Dept. CE-958

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LANSDALE TUBE COMPANY DIVISION

LANSDALE, PENNSYLVANIA

TRANSISTOR CENTER U.S.A.

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PROVIDE THE ACCURATE POSITIONING ESSENTIAL FOR NUMERICAL CONTROL

Beaver Precision ball lead screws on all three axes provide the basic measuring and actuating elements which simplify the design of this tape controlled milling machine.

Beaver ball screws move table of this Bridgeport Mill in response to signals from the Electronic Control Systems, Inc. "Digimatic" control and are typical of those now in use on numerically controlled machine tools of all types.

If it's numerically controlled, tape or card, it is more than likely equipped with Beaver ball screws. Our engineers are available to you for consultation – can we help you improve the design of your equipment?



Beaver Precision Products INC.
CLAWSON, MICH.

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individual basis and at individual expense.

Books and other printed material in the public domain may be shipped to the Soviet Union without an export license, but a customs declaration is required. The declaration and the package should carry the letters GTDP –General Technical Data Publications.

The only official agency which exchanges books with the Soviet Union is the Gift & Exchange Div. of the Library of Congress, headed by Jennings Wood. This agency is specifically charged with the responsibility for exchanging books and technical information with a large number of countries, including the Soviet Union, under the Brussels Convention of 1886. Ed.

Where specific papers are requested, the awkward procedure is required of asking the author to send to the U. S. S. R. complimentary copies of his papers if he feels so disposed. It appears that such a transmission of technical papers could be handled better by the professional society responsible for their publication and that the Soviet engineers should be informed that it would be more convenient if they would direct such requests to those organizations.

R. J. Kochenburger
University of Connecticut
Storrs, Conn.

Preprints of technical papers may be made available to Soviet scientists, provided they are really going to be published. Dept. of Commerce officials feel that it would be just fine if the technical societies handled the transmission of papers. Ed.

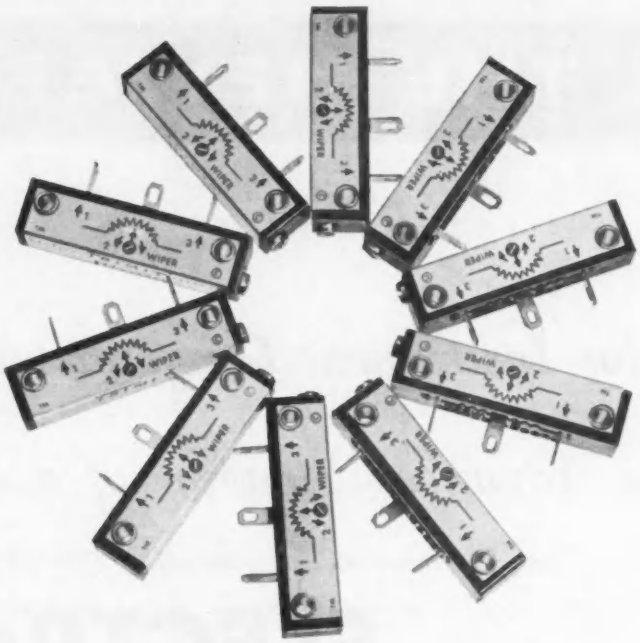
Information please—literature

To the Editor—

From Control Engineering No. 3, 1958, page 170, I see that there was a paper presented at the sixth Anglo-American Aeronautical Conference, Folkstone, England, Sept. 9-12, 1957, with the title, "The Electrical Control of Power Plants", by G. M. Sturrock. Since I am very interested in this paper, I ask you to tell me to whom I must write for this paper.

Harry Ludwig
Dresden, Germany

The author still has a few copies of his paper left. Reach him at Ultra Electric, Ltd., London W 3, England. The full proceedings of the Folkstone conference are to be published in the autumn by the Royal Aeronautical Society of London. Ed.



HERE'S TRIMIT® ... A NEW TYPE OF ADJUSTMENT POTENTIOMETER FOR COMPUTERS, CONTROLS, COMMUNICATIONS, TEST EQUIPMENT

Compared with the average control-type single-turn rotary potentiometer, TRIMIT adjustment *accuracy* is a 33:1 improvement. TRIMIT provides 9000° of rotation instead of 270°. Easier repeatability, too.

TRIMIT *geometry* is a 6:1 to 12:1 improvement—you can mount 12 units in a panel area of only 1 square inch. They fit flat against printed circuits, into tight corners, between components.

The screwdriver-adjusted TRIMIT settings are extremely *stable*. The screw-actuated mechanism is virtually immune to shock or vibration.

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Taylor Instrument Companies will present

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ELECTRONIC INSTRUMENTS

as well as the latest advancements

in pneumatic instrumentation

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THE TAYLOR BOOTHS

The new line embodies the latest concept in electronic instrument design, while incorporating many time-proven convenience features originated by Taylor, such as front adjustment, plug-in components and truly rectilinear charts.

Also the TRANSCOPE* Controller and Recorder — pace setters in the pneumatic field — mark a giant step forward in compactness, convenience and performance.

Plus the SENSAIRE* Temperature Transmitter — hailed as an outstanding development in more economical pneumatic instrumentation.

Key representatives from our Application Engineering and Sales Departments will be on hand at the Show to counsel you with your instrumentation problems. And if you have branch plants overseas, you will be interested to learn of Taylor's recently expanded facilities — and our plans for further expansion.

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Capable of *independent phasing* of resistance elements in relation to shaft position . . .

High performance in extra-small space, yet meeting precision tolerances . . .

DO YOU LOOK FOR THESE FEATURES?

- **Elimination of clamping rings.**
- **Complete independence of each cup in ganged assembly for phasing operations.**
- **Superior performance and life.**
- **Maximum reliability and stability.**
- **Sturdy terminals molded in place.**
- **Thermally compatible.**

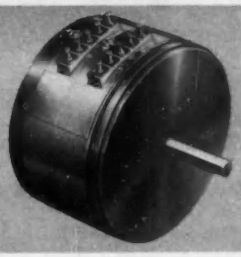
IF SO, YOUR PRECISION POTENTIOMETER

BECAUSE YOU JUST PICKED...

CLAROSTAT VARI/PHASE® PRECISION POTENTIOMETER

CLAROSTAT SERIES 57 ½" PRECISION POTENTIOMETER

THAT LOOKS LIKE THIS





AND WORKS LIKE THIS...

Designed to meet applicable specifications of military aircraft industry and general electronic equipment, the Clarostat Vari/Phase offers an exclusive design whereby phasing of individual units in ganged assemblies may be accomplished by a simple, single operation. Available in four series ranging from ⅞" to 3" in overall diameter, and from 2- to 6-watt ratings. Resistance range depending upon unit size, in standard units running up to 200K ohms.

New Hi-Load winding element in the Clarostat Series 57 ½" dia. potentiometer, combined with an advanced rotor and brush assembly, meets "more performance in less space" requirements of the most critical user. Unit body is nickel-silver, with a thermally compatible cover in which terminals are molded in place. Rated at 1.5 watts, with resistance ranges up to 40K ohms. Linearity is plus/minus 2% standard; plus/minus 1% special.

and furthermore

Clarostat offers *unparalleled* design, testing and model-making facilities to meet your *unusual* precision potentiometer requirements. For extreme environmental conditions, Clarostat maintains the most complete precision resistance encapsulating facilities in the industry. Special shaft and bushing configurations, coupled with Clarostat encapsulation ("POTPOT"®) result in units that withstand the most adverse moisture, salt spray and dust conditions.

POTENTIOMETER I. Q....

For controlling from 2 to 20 circuits simultaneously, also available with switch . . .

- Life up to 2,000,000 cycles.
- Choice of continuous or limited rotation.
- Rugged construction electrically and mechanically.

Multi-turn adjustment of resistance for greater accuracy in effect and readout...

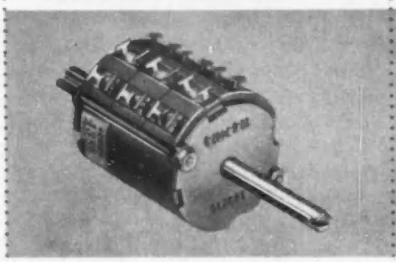
- Greatest winding length in given outside diameter.
- Maximum immunity to environmental conditions.

Padding or trimming effect in minimum space, under adverse environmental conditions.

- Rugged mechanical and electrical construction.
- Low-temperature coefficient wire.
- Positive clutching and de-clutching mechanism.

INTELLIGENCE QUOTIENT IS O. K.!

CLAROSTAT SERIES 42 PRECISION POTENTIOMETER



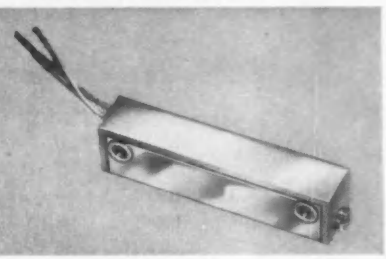
A highly versatile precision potentiometer offering a choice of continuous or limited rotation. Individual units are encased in a high dielectric phenolic and ganged by means of threaded rods and metal end-plates. Electrical rotation is 291° plus/minus 3%. The Series 42 exceeds MIL-R-19 specifications where applicable. 3-watt power handling capacity, with linear resistance range of from 1 to 100K ohms, and a tapered range up to 350 ohms per degree of rotation. Resistance tolerance is plus/minus 5%.

CLAROSTAT MULTI-TURN PRECISION POTENTIOMETER



A superior material, electrically and mechanically, is used for the housing, making possible a thinner shell which in turn provides up to 20% more winding length for given outside diameter. This means a greater overall resistance range and finer resistance resolution, size for size, than other comparable units. Available in three sizes from .875" to 2" dia., and from 3- to 6-watt ratings, with resistance ranges depending upon size selected. All units are 10-turn, with 5% resistance tolerance standard, 1% special.

CLAROSTAT PADOHM® PRECISION POTENTIOMETER



A 25-turn rectangular precision potentiometer built to the highest standards of design and materials. A low-temperature coefficient wire is wound on a special ceramic core for maximum stability. Effective electrical travel is 98% minimum of mechanical travel. End resistance is 1% of maximum overall resistance. Available in two types: 1.25 watt and 0.25 watt, derated to "0" power linearly at 135° and 105° C. respectively. Resistance range of from 100 to 20K ohms employing plus/minus 20 ppm wire standard.

37 YEARS OF RESISTANCE LEADERSHIP

...experience you can buy— only at CLAROSTAT

... LITERATURE ON REQUEST

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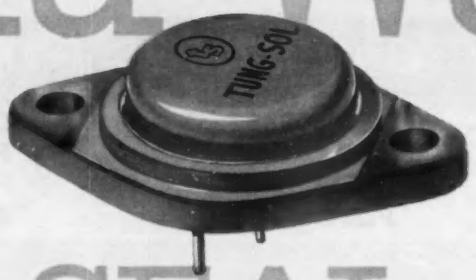
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TUNG-SOL POWER TRANSISTORS IMPROVED THREE WAYS BY:

NEW

Cold-Weld



SEAL

Tung-Sol's new true cold-weld seal represents a major advance in transistor technology. An exclusive Tung-Sol development, cold-weld sealing increases TO-3 outline package efficiency and brings designers a threefold bonus in over-all transistor performance.

Improved thermal qualities. The cold-weld process produces a hermetic, copper-to-copper seal and makes possible a 100% copper transistor with thermal properties superior to previous high power types.

Improved reliability. Cold-weld encapsulation eliminates heat damage, "splash", and heat-caused moisture that can impair transistor performance.

Longer efficient life. Even through temperature fluctuations that cause "breathing", the cold-weld seal stays vacuum-tight, moisture-proof—result of actual integration of the copper molecules during sealing.

Tung-Sol power switches with the new cold-weld seal withstand the most rigid combination of tests given any transistor—the 100 psi "bomb" immersion test and the critically sensitive Mass Spectrometer leak test. Further, they meet all military environmental requirements. For full data on the improved Tung-Sol types . . . to fill any transistor need, contact: Semiconductor Division, Tung-Sol Electric Inc., Newark 4, New Jersey.

THESE TUNG-SOL HIGH POWER (TO-3 OUTLINE) TRANSISTORS FEATURE THE NEW, COLD-WELD SEAL

Type	BV_{CES} (V_{BE} = +1.0v) Volts (Min)	BV_{CEO} (I_B = 0) Volts (Min)	h_{FE} (I_C = 1.0 A)	h_{FE} (I_C = 2.0 A)
2N378	—40	—20	50	30
2N379	—80	—40	50	30
2N380	—60	—30	70	50
2N459	—105	—60	50	30



TO-3

IMPROVED SPECIFICATIONS OF TUNG-SOL COLD-WELDED HIGH POWER TRANSISTORS.

Collector Dissipation @ 25°C*...50 Watts
Collector Dissipation @ 55°C*...25 Watts
Thermal Resistance.....1.2° C/Watt Max.
I_{CBO} @ V_{CB} = —25v T = 25°C...0.5 Ma Max.
I_{CBO} @ V_{CB} = —25v T = 85°C...7.5 Ma Max.
Storage Temperature.....—55 to +100°C

*Mounting base temperature

TUNG-SOL®

Harry W. Mergler

puts punched tape in control

At the National Advisory Committee for Aeronautics' Cleveland Laboratory, machinists turning out experimental parts for aircraft, missile, and space tests were used to seeing unusual sights. But none was stranger than what they saw one day in 1950 when the analog computer with its amplifiers and servos was brought into the shop for the first time.

A milling machine operator hovered over his machine 400 ft down the aisle, watching as engineer-scientist Harry Mergler turned dials on the computer, which had been set up against one wall. Six wires snaked along the floor connecting the two machines. As Mergler raised his hands in a prearranged signal, the machine operator poised; and when Mergler dropped his hand, the operator fed the cutter into the work.

This first application of a computer to control a machine tool was unexpectedly successful. The complex-shaped cam that had stymied the shop was milled out in slightly more time that it would have taken to machine a more conventional part.

For soft-spoken, deliberate Harry Mergler, himself overawed by the total success of his brainchild, it meant the turning point in a career. Mergler turned from a computer scientist to a control engineer, one of the first specialists to apply information theory to program control.

Today, Harry smiles every time he thinks about the awkward setup for milling that first cam. "Looking back now," he says, "what we did was ludicrous. But funny as it was, it worked. And it started us thinking about using digital machines."

Harry Mergler got his start in the control field in a most indirect manner. World War II cut off his studies at MIT before he could earn a degree. While flying for the artillery as a liaison pilot, he became interested in airborne fire direction equipment, started puttering with a computing sight. His part-time research work brought about his transfer to the Fire Control Research Laboratory at Frankford Arsenal, where he had an opportunity to work with analog computer specialist Dr. John Tappert.

Mergler credits Tappert with developing his interest in computers, an interest so strong that after the war Mergler enrolled at Case Institute of Technology to major in physics. In 1948, he earned his BS degree and joined NACA as a scientist in the analog computer development group. He continued his studies at Case, earning a MS degree in 1950.

The success of the milling machine control project accelerated his studies and started him working full



tilt on the application of advanced techniques of program control. His concentration was such that when he received his PhD degree in 1956, a faculty observer remarked that this was probably the first doctorate ever granted in "program control and recorded information theory". His doctoral dissertation, "Numerical Machine Tool Control Operating from Coded Paper Tape", led to a number of patents which Harry has assigned to machine tool builders.

In 1957, Mergler left NACA to return to Case as a full-time assistant professor in the Mechanical Engineering school. He divides his time between teaching servo and information theory courses, and consulting. In the last 18 months, he has supplied the technical know-how behind the design of a number of punched-tape controlled machines. Now he'd like to branch out to tape control chemical processes.

The slow-speaking engineer with the quick, dry wit is in an enviable position. Says he, "I'm thoroughly convinced that I have found what I want to do and where I want to be."

And this deep feeling of satisfaction was even heightened recently. Already the doting parent of two girls, Myra 6, and Marcia 4, Harry became a father again in July when his wife presented him with a son. "Just what I ordered," said Harry proudly, "and that's what I call real control."

VRPS Kepco for the most complete line of POWER SUPPLIES

REGULATION 0.1% and STABILITY

VOLTAGE REGULATED POWER SUPPLIES

MODEL	OUTPUT VOLTS DC	OUTPUT AMPERES DC	OUTPUT IMPEDANCE DC-1KC	OUTPUT IMPEDANCE 1KC-100KC	SIZE W	SIZE H	SIZE D
SC-18-0.5	0-18	0-0.5	.04	.4	8¼"	4⅝"	13⅝"
SC-18-1	0-18	0-1	.02	.2	8¼"	4⅝"	13⅝"
SC-18-2	0-18	0-2	.01	.1	8¼"	4⅝"	13⅝"
SC-18-4	0-18	0-4	.005	.05	19"	3½"	13"
SC-36-0.5	0-36	0-0.5	.08	.8	8¼"	4⅝"	13⅝"
SC-36-1	0-36	0-1	.04	.4	8¼"	4⅝"	13⅝"
SC-36-2	0-36	0-2	.02	.2	19"	3½"	13"
SC-3672-0.5	36-72	0-0.5	.15	1.0	8¼"	4⅝"	13⅝"
SC-3672-1	36-72	0-1	.08	.8	19"	3½"	13"

Patent Pending

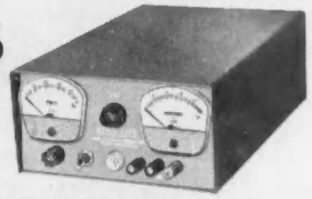
(TUBELESS)

TRANSISTORIZED

SHORT CIRCUIT PROTECTED

- **REGULATION:** 0.1% for line changes 105-125 volts at any output voltage in the range minimum to maximum.

  0.1% or 0.003 volt for load changes 0 to maximum (whichever is greater) at any output voltage in the range minimum to maximum.
- **RIPPLE:** 1 mv. RMS.
- **RECOVERY TIME:** 50 microseconds.
- **STABILITY:** (for 8 hours) 0.1% or 0.003 volt (whichever is greater).
- **AMBIENT OPERATING TEMPERATURE:** 50°C maximum. Over-temperature protection provided. Unit turns off when over-temperature occurs. Power-on-off switch on front panel resets unit.
- **TEMPERATURE COEFFICIENT:** Output voltage changes less than 0.05% per °C.
- **SHORT CIRCUIT PROTECTION:** No fuses, circuit breakers or relays! Designed to operate continuously into a short circuit. Returns instantly to operating voltage when overload is removed. Ideal for lighting lamps and charging capacitive loads.
- **OVER-CURRENT CONTROL:** Can be set from 0 to 120% of full load. Current is limited to preset value for any load including short circuit.



Model SC-18-2-M



*Two units mounted in Rack Adapter RA-2



Model SC-18-4-M

- **REMOTE PROGRAMMING** at 1000 ohms per volt is provided. Remote programming allows mounting a voltage control at a remote point.
- **REMOTE ERROR SIGNAL SENSING** is provided to maintain stated regulation directly at load.
- **CONSTANT CURRENT OPERATION:** These units can be set up for constant current operation without internal modification.
- **POWER REQUIREMENTS:** 105-125 volts, 50-65 cycles. 400 cycle units available.
- **OUTPUT TERMINATIONS:** DC terminals are clearly marked on the front panel. All terminals are isolated from the chassis. Either positive or negative terminal of each DC output may be grounded. A terminal is provided for connecting to the chassis. The DC terminals, the remote programming terminals and the remote error signal sensing terminals are brought out at the rear of the unit.
- **CONTROLS:** Power-on-off switch, one turn voltage control, on front panel. Over-current control on rear of unit. Ten turn voltage control available on special order.
- Continuously Variable Output Voltage. No voltage switching.
- Suitable for square wave pulsed loading.
- Either positive or negative can be grounded.
- Units can be series connected.
- High efficiency
- Low heat dissipation.
- Compact, light weight
- For bench or rack use.
- Color: Gray hammertone. (Special finishes available).

ORDERING INFORMATION:

Units without meters use model numbers indicated in table. To include meters add M to the Model No. (e.g. SC-18-1-M).

*Rack adapter for mounting any two 8¼" x 4⅞" units is available. Model No. RA2 is 5¼" high 19" wide.

*Rack adapter for mounting any one 8¼" x 4⅞" unit is available. Model No. RA3 is 5¼" high 19" wide.

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INDEPENDENCE 1-7000

Largest Automatic Freight Yard Started in Canada

Canadian National Railways has broken ground for what it claims will be the largest automatic freight yard in North America. Trackage will total 165 miles, spread over 84 tracks which spread out like a giant fan to make up the classification yard.

The 84-track yard can be used as one yard or it can be split in half to form two 42-track classification yards operated simultaneously.

The yard operator assigns tracks to freight cars by pushing buttons. Television cameras pick up freight car numbers which are identified as to load and destination in a central control room. From here this identifying information with the track assignment is teletyped to the yard operator in a control tower.

The system will have a computer to help keep cars rolling at the proper speed. As a car begins its descent it is automatically weighed; the distance it must travel to its coupling point is measured. Wind temperature, and resistance of the car are also considered. With these inputs, the computer can determine how fast to let the car roll.

If measurements indicate the car is rolling too fast, retarders are automatically applied, slowing the car down by squeezing steel jaws against the sides of the car wheels.

This yard, being built at Cote de Liesse, is expected to be in operation by 1961. Cost is estimated at $28 million. It will sort 7,000 cars per day.

New Space Facility for Long Island

Six laboratories devoted to a study of space technology will be built in a new $14 million engineering and research center at Farmingdale, L. I. by Republic Aviation Corp. The building is part of $35 million that Republic will spend over the next four years to make the company a factor in the missile and space field.

Major fields of study: a Guidance and Control System Development Laboratory to work with optics, infra-red, inertial components and servomechanisms; an Electronic Development Laboratory to develop systems and electronic components; a Space Environmental Development Laboratory to simulate altitudes of space flight; and a Re-entry Simulation and Aerodynamic Development Laboratory for reentry studies.

Photocells Size Cars for Automatic Garage

First completely automatic parking garage has started operation in Basel Switzerland at the Hotel International. Built at a cost of $4 million, the garage houses 374 cars over 8 floors. Three elevators park cars at the rate of three a minute, discharge them in 30 seconds at a side exit.

As a car drives into the garage, photocells scan the overall height (lockers are different sizes to save space while accommodating both small sportcars and large sedans), send this information to a special purpose computer in the basement which picks a locker for the vehicle.

Meanwhile, the garage's single operator records date and time on his controller, as well as the number of one of the nine parking ramps, then keys out license numbers and any servicing the car requires. All these details are entered on a control slip which serves as the car owner's receipt. The driver then drives to the designated parking ramp, leaves his car, and pushes a button. The car is automatically taken to the locker assigned it by the computer.

A similar garage is planned for New York City to be built by Speed-Park, Inc., for Columbia University.

TRANSIENTS IN CONTROL

First continuous-process asbestos cement pipe plant in the U. S. uses electromechanical controls and electronic scales. Built by the Johns-Manville Corp. at Denison, Tex., the controls direct the weighing of each of three materials in the pipe, then mixing the materials in proper proportions, finally feeding mix into the continuous pipe machine. Low-level limit switches provide most automatic operation of J-M's nine pipe plants.

•

Guidance system of Air Force's defunct Navaho program has been brought back to life for use in Navy's Polaris program. Navy's Bureau of Ordnance has awarded a contract to Autonetics Div. of North American Aviation to design and fabricate the system, which will pinpoint the location of the missile-carrying ship. The shipboard version, mounted on a gyro-stabilized platform, will accurately sense all accelerations, measure them, and provide results in the form of continuously available and precise position and velocity information.

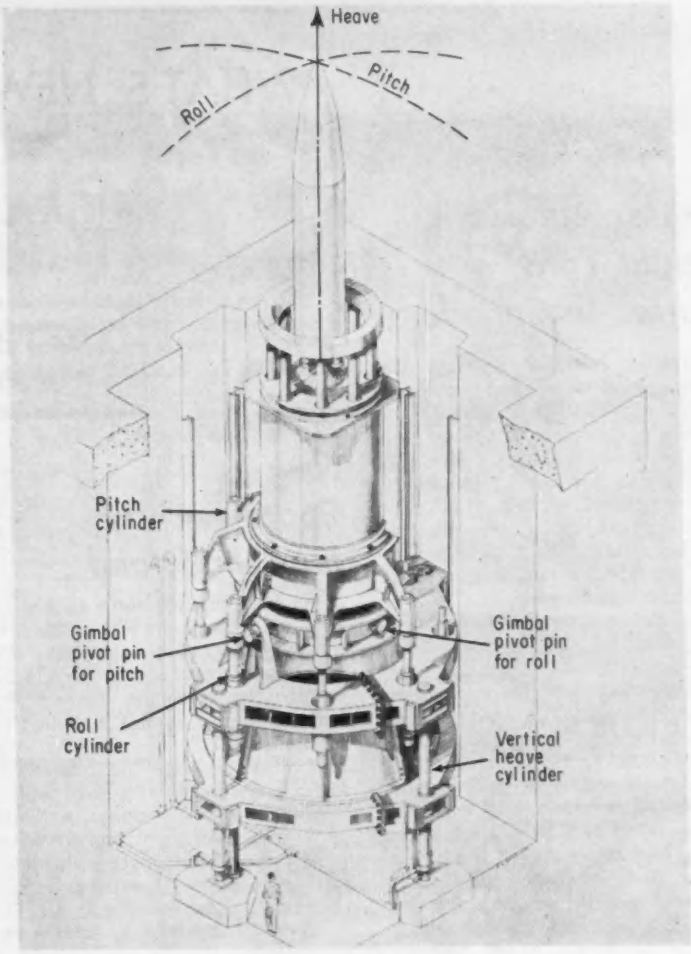
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New telemetry technique is being developed by Applied Science Corp. of Princeton (ASCOP) for the military services. Called statistical telemetering, the technique analyzes statistically high frequency data in the air, then transmits only the low frequency results that are actually slowly varying. Major advantage claimed for the new system: conservation of transmission bandwidth and shortening of data reduction time on the ground.

•

New thermionic converter is being studied by General Electric. Last year GE showed off a gas-filled device which converted heat to electricity. The new converter, however, uses high vacuum, sealed in by a combination of metallic and ceramic discs. Major advantage: increased efficiency.

Massive "Rock-'n'-Roll" machine duplicates any ship motion; it's regulated by an electrohydraulic control system that uses a throttle valve with logarithmic characteristics.



Simulator consists of a pair of large diameter and concentric cylindrical rings which are gimbal-mounted much like a rate gyro to permit angular motion of the axis of the inner cylinder in roll and pitch. In heaving motion, simulator rides up and down on the railed tracks.

Giant POLARIS Launcher Simulates the Sea

When the Navy's intermediate range ballistic missile Polaris is test-fired at Cape Canaveral, test engineers will dictate the kind of launching ship and the condition of the sea —even though the firing takes place on dry land. That's because Polaris will be launched from a massive 200,000-lb gimbaled simulator capable of duplicating any ship motion.

Purpose of the simulator is to determine the conditions under which a missile with moderate take-off acceleration can be launched safely from a moving platform. At the same time, it will test missile components under actual ship motions.

Extending into a 47 ft concrete pit, the device (called a shaker by designer-builder Loewy-Hydropress Div. of Lima-Baldwin-Hamilton and a "rock-'n'-roll machine" by Navy men) is designed to launch the missile from firm ground. Three electrohydraulic control systems direct the below-ground mechanism to provide, to order, three ships motions: heave (vertical up and down motion), roll (side to side movement, rotation about the longitudinal axis) and pitch (forward and back movement, rotation about the athwartship axis). In first launchings, instructions will be programmed into the device by dials, a separate dial for each movement. Later, three-channel magnetic tape recorded on a ship at sea may run the simulator.

Although ship motion has 6 deg of freedom, three of rotation and three translation, analysis has shown that only roll, pitch, and heave produce components of displacement, velocity, and acceleration capable of affecting missile-launch characteristics. For example, sidle (another translatory motion) appears as a contribution to pitch; yaw (rotation about a vertical axis) produces angular azimuthal changes easily correctible by rotating the launcher.

The simulator's motion capabilities

MILITARY ASPECTS OF THE SIMULATOR

To military men, the Loewy-Hydropress shaker introduces a totally new concept in warfare, one rapidly gaining favor among missilemen: underground launching of missiles.

The simulator can hold a 40-to-50-ton object without requiring a giant gantry that not only tips off the location of a missile firing site, but reveals when a firing is imminent (since it has to be rolled away from the launching pad just before a launching). As a firing site, it is expertly camouflaged at all times.

From a tactical standpoint, underground launching appears to be a technique of infinite capabilities. It provides for immediate retaliation, the lack of which has already dimmed the potentialities of the Atlas and the yet-to-be-tested Titan missiles. Test firings of the Navy's Polaris, it is predicted, will make underground launching of solid propellent missiles even more popular.

Test vehicle launchings of the Polaris were scheduled to start in mid-August. First units will be 40-ton concrete tubes, fired as a final check of the shaker mechanism. During these tests, the shaker will be programmed on sinusoidal curves based on actual cruise experience recorded aboard the U.S. submarine Mariposa last year.

A special safety program, nicknamed "Lace", has been devised to guarantee that Polaris shoots will stay away from civilian areas. During missile testing, potential firing time, will be limited to a period of three-tenths of a second, during which the missile will be aimed in the down-range direction. The Navy plans all Polaris firings at a single predetermined launch azimuth, elevation and direction. As the shaker traverses through a programmed motion, the electronic firing mechanism becomes active only during the 0.3 sec after it has reached the designated firing position.

This directional limitation is for safety and instrument purposes only (testers want to keep the missile within range of telemetry equipment, of course). In a tactical situation, the shaker could launch a missile in any direction.

By mid-August, costs of the simulator had passed $3 million. Loewy-Hydropress will operate the shaker until completion of the third test shot. After that Polaris prime contractor Lockheed Aircraft Corp. will take it for the rest of the Polaris test program.

are sufficient to make even the best seaman seasick. It is reported the device can heave a maximum of 8 ft up and 8 ft down from a neutral center point; it can roll a maximum of 14 deg from the center and pitch a similar angle. Time of a complete cycle ranges from a minimum of 6 sec to 26 sec.

To do this, Loewy drives 8 hydraulic cylinders with water at a pressure of 2,900 psi.

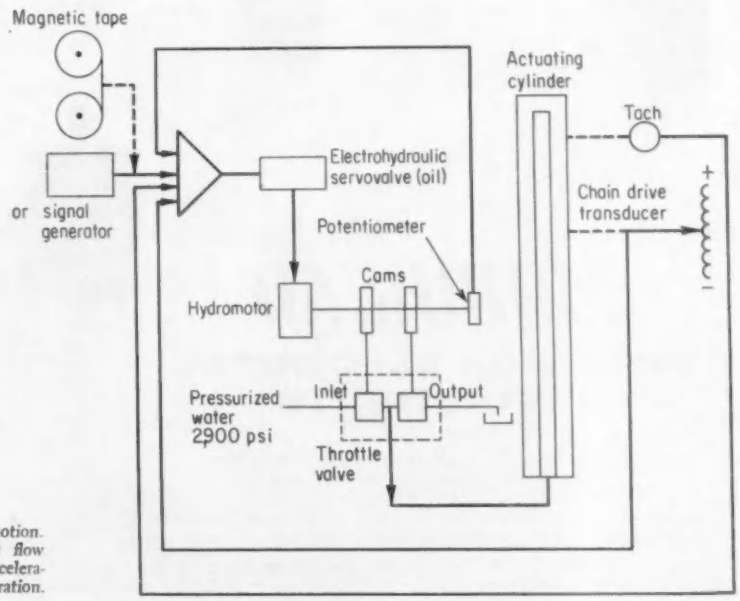
The heave motion relies on the weight of the simulators for down motion. Hydraulic pressure heaves the unit upward; the weight of the simulator helps bring it back.

For roll and pitch, the machine uses constantly loaded pistons instead of weight. These motions are actuated by four cylinders, two working and two "balancing". Because of the balancing, positive action need move in one direction only; the balancing cylinders return the mechanism in the opposite direction. For example, to introduce roll, pressure in the working cylinder is increased, the piston moves upward, causing the frame to rotate about the pin. To return, the pressure in the working cylinder is reduced and the force in the balancing cylinder (where pressure is maintained at 2,900 psi) drives it back.

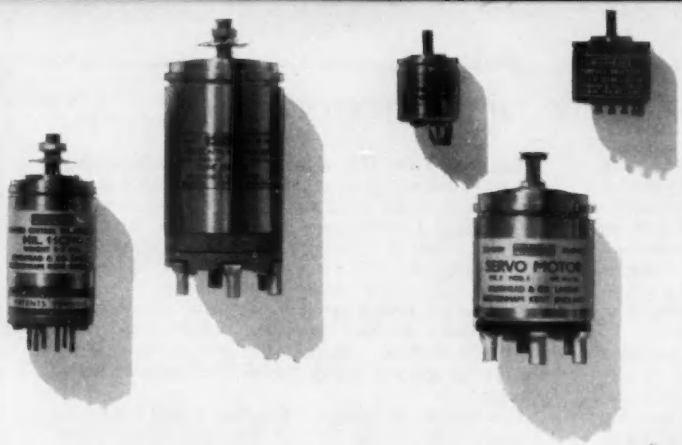
"Considering the complexity of the job to be done, the control system is relatively simple—but quite interesting" says Loewy-Hydropress control engineer Leo Robbins. Amplitudes and phases of the three motions are set into the system by dials associated with three independent function generators. A pushbutton starts the motion when all instructions have been inserted. To control heave, for example, a sine wave signal from the function generator (a precision variable-speed motor geared to a sine pot) goes into a differential amplifier, where it is amplified to actuate an electrohydraulic servovalve.

The valve controls the action of a hydromotor, which moves cams to operate the four-way throttle valve that is the key to the simulator's smooth action. An unusual feature permits the throttle valve to open in a logarithmic fashion so that it is as sensitive at low speeds as at high speeds, and to move as fast when fully open as when fully closed.

There are three feedback loops in each control system. A potentiometer on the camshaft feeds back a position signal to the differential amplifier. A transducer is placed on the working cylinder to report its position. And finally, a tachometer on the cylinder reports its instantaneous speed. Furnishing a signal proportional to velocity, the tachometer output will be also differentiated to furnish velocity



Schematic of control system for one motion. Control is maintained by regulating inlet flow and pressure to the cylinders during acceleration and regulating outlet flow during deceleration.



Synchros galore!

All shapes and sizes of synchros and servos for every conceivable duty, built to established specifications and ready for immediate delivery. MUIRHEAD Synchros are backed by more than 20 years' synchro manufacturing experience.

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and acceleration signals for recording and indication. The transducers can also feed attitude data to the missile guidance system up to the time of launching.

When a Polaris missile is scheduled for firing, the operator of the simulator will receive instructions to conduct the test at a stated condition. A previously prepared chart supplies information for this specified condition. The chart will show the amount of roll, the pitch and the heave.

These instructions also include amplitude motion, period, and the phase relation between the three movements. Variations in amplitude are accomplished by attenuating the voltage of the signal generator. Changing the motor speed varies the period.

Electromagnetic clutches between the motors and the gearing set up the desired phase relationship. The clutches are arranged so that any one, any pair, or all three resolvers can be driven from the same motor in any desired phase relation. All these inputs are inserted by turning dials. It takes about 2 min to ready the controls of the simulator.

When all the information is set into the dials on the control board, the operator pushes a button to start the simulator. The sea-imitating machine then keeps operating until a stop button is pushed. It's possible to change the amplitude of a motion during the test; but to uncouple synchronous motion requires bringing the motion to zero.

It is also possible to insert a measured list into the machine. Setting in a list puts a bias on the signal generator so that there is a zero shift.

The big simulator was completed in July and checking-out operations were finished in August.

A-Plant for Alaska

U.S. Army has ordered a second packaged atomic power plant, this one to be built at Fort Greely, near Fairbanks, Alaska. The 1,700-kw pressurized water reactor plant will supply all the power normally used by the Fort. Approximately half the thermal output will be used to generate electricity; the rest for space heating. ALCO Products, Inc., will supply all primary system components. General Electric Co. is developing a transistorized instrument system. It will measure power level of the reactor and provide output signals for control.

maintain and control reliability

with new PRE-PROGRAMMED INSTRUMENTATION

NEW ROBOTESTER — IMMEDIATE AID TO IMPROVE MAINTAINABILITY OF EQUIPMENT RELIABILITY

A bold imaginative concept has evolved from Lavoie Labs in the form of a Programmed Instrumentation Approach with Failure Prediction. Designed for the **active control** of maintainability and reliability of electronic equipment in aircraft, missile and weapon systems.

The universal-tape programmed performance checking Robotester is versatile and flexible and is the basis of this forward-thinking Lavoie program.

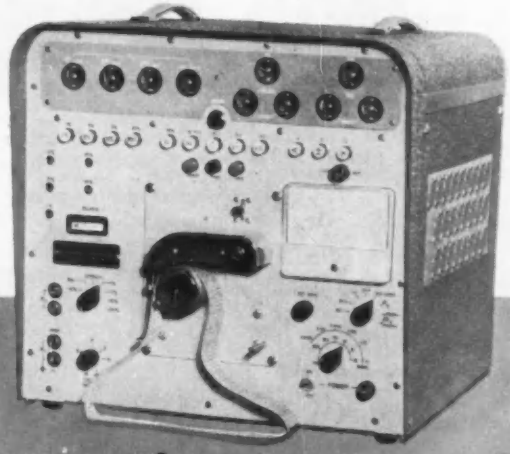
The Robotester itself expands checkout capabilities and slashes 80% of final test time. Operational testing and production line check out is accomplished through continuous, high-speed sampling and comparison . . . split-second recognition, isolation and identification of abnormal functions.

Nominal circuit values and specified tolerances are tape-punched in minutes to accommodate voltages (AC and DC) from 0.5 to 500 volts; Hi Pot to 500 volts; resistances from 1 ohm to 9.99 megohms; and tolerances of 1%, 5%, 10% and 20% of nominal. A total in excess of 60000 tests possible . . the Robotester will check any two circuit points at rates up to 100 tests per minute.

Write today for complete technical information and specifications on the New Robotester.



Write on company letterhead for "Lavoie Programmed Instrumentation" . . please specify application.

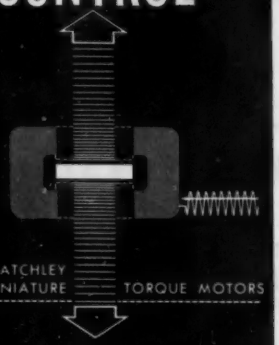


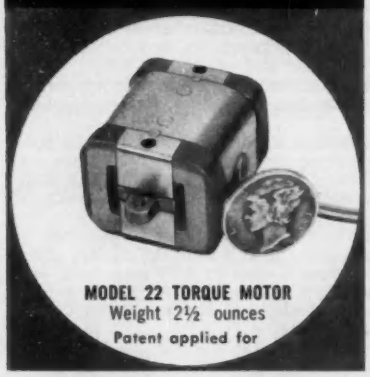
Lavoie Laboratories, Inc.

MORGANVILLE, NEW JERSEY

DESIGNERS AND MANUFACTURERS OF ELECTRONIC EQUIPMENT

POSITIVE SERVOVALVE CONTROL





MODEL 22 TORQUE MOTOR
Weight 2½ ounces
Patent applied for

Atchley high-efficiency, reliable torque motors are used extensively in many military servosystems to drive hydraulic and pneumatic servovalves. Their all-welded construction assures dependable performance under adverse environmental conditions of vibration, shock, and temperature to 400° F.

The design is simple and rugged. All motors must pass rigid acceptance tests, and a certified calibration curve is supplied with each motor. Atchley motors are offered in four sizes, with maximum force outputs from 1.5 to 13 pounds.

For more information, write for data file CE-532-1.

Raymond Atchley, Inc.

2340 SAWTELLE BOULEVARD
LOS ANGELES 64, CALIFORNIA
TELEPHONE + GRANITE 9-8626

CIRCLE 22 ON READER-SERVICE CARD

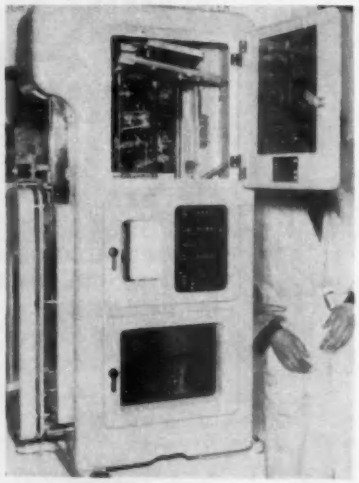


Japan International Trade Fair

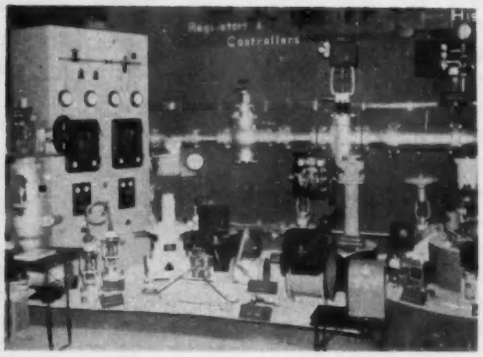
. . . was truly international in character. But, as these photos taken by CtE's Japanese Correspondent Kazuto Togino show, the variety of measurement and control equipment reflects the fast growing rise of the Japanese control industry (CtE, July, '58, p. 69).



Liquid-level control equipment was built to Japanese design by Kobe Kogyo Corp. It uses a radioactive isotope in the level gage.



Switzerland sent this automatic yarn strength tester built by the Uster Factories for Apparatus & Machines. Hystrogram (at bottom of machine) plots strength vs. number of times steel ball drops on yarn without breaking it.



Japanese process controllers and regulators are appearing in larger numbers. This equipment, Japanese designed and manufactured, was exhibited by Nakakita Seisakusho Co., Ltd.

AT LAST . . .

A COMPLETELY RELIABLE

all ELECTRIC

VALVE POSITIONER

NORWOOD CONTROLS

ON DISPLAY AT BOOTH 974-1071 I.S.A. SHOW



- TRANSISTORIZED
- SELF-LUBRICATING
- EXPLOSION-PROOF
- EASILY ADJUSTABLE
- MANUALLY OPERABLE
- LOW STAND-BY POWER
- UNIQUE BRAKING... prevents valve oscillation

Norwood's new all-electric positioner completely eliminates the need for auxiliary hydraulic or pneumatic valve actuating systems and operates from most standard electric controllers. A 1/40 h.p., 2-phase, induction-type electric motor drives the actuating shaft through a highly efficient self-lubricating gear train and ball-screw mechanism.

Stroke can easily be field-adjusted from ½" to 2". Shaft speed is .15 in./sec. Maximum thrust is 1000 lbs. and built-in limit switches prevent valve damage.

Shaft oscillation is effectively prevented by means of a unique, electro-mechanical braking system which prevents movement of the shaft unless the motor is energized or unless it is being operated manually. The combination of an anticipatory circuit with dynamic braking narrows the dead band and ensures repeatability of position to within ¼%. Stand-by power requirement is as low as 50 watts.

For further information, write for data sheet B158-3.

Norwood Controls Unit, Detroit Controls Division, 938 Washington St., Norwood, Mass.

AMERICAN-Standard

DETROIT CONTROLS DIVISION



CEC's new potentiometer pressure pickups



CEC's new potentiometer pressure pickups



CEC's new ... eter pressure pickups

airborne applications have been carefully considered in the design of Consolidated's pot pressure pickups. Minimum size and weight... mounting convenience through an integral flange base and parallel fittings... superior resistance to shock and vibration... are immediately apparent advantages. In both pickups, pressure fluid remains external to the wiper system, precluding potentiometer contamination by the measured media. Operating temperature range is −65°F to 200°F.

LOW-PRESSURE TYPE 4-380 is designed for absolute, gage, and differential pressure measurements of non-corrosive fluids in ranges up to 100 psi. Flexure pivot assembly gives minimum hysteresis (0.6%), friction of less than 1%, and zero backlash. Linearity is ±1%. Weight, only 8 oz.

HIGH-PRESSURE TYPE 4-381 is offered in differential and gage models from 600 to 5,000 psi, and absolute models from 600 to 1500 psi. Design features solid construction of 303 stainless steel, fail-safe case that takes 10,000 psi, vibration resistance to more than 25 g's in a small 2″ x 2″ x 1⅛″ package.

For complete information, contact your nearest CEC sales and service office, or write for Bulletins CEC 1604-X9 and 1611-X3.

Transducer Division CEC

FOR EMPLOYMENT OPPORTUNITIES in this progressive company, write Director of Personnel.

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

RECOGNIZED LEADER IN GALVANOMETERS—TELEMETRY, PRESSURE AND VIBRATION INSTRUMENTATION

CIRCLE 24 ON READER-SERVICE CARD

WHAT'S NEW

AICHE Jubilee Meeting

Process control engineers envision a new grouping of unit operations, one based on similarities of process dynamics rather than mechanical operations of the current basis.

When they gathered in Philadelphia in June to celebrate the Golden Jubilee of the American Institute of Chemical Engineers, process engineers did some looking ahead as well as looking back. To those most interested in process control one thought crystalized: the outlines of control problems become sharper as process control technology advances.

One area that seems to be coming into a lot sharper focus for the control engineer is the classification or grouping of the so-called unit operations in the process field. Chemical engineers frequently put them into 18 groups, based on the mechanical fundamentals of the process. Other classifications are finer, extending into more than 18 groups. But at the Jubilee process control sessions, listeners heard suggestions for less than 18 classifications, oriented to the needs of the control engineer rather than the process specialist. These derive from similarities of process dynamics.

• **By rates**—In one paper, "The Concepts of Process Dynamics", Princeton University's E. F. Johnson grouped operations according to their rates of actions. Johnson offered three major classifications: physical, chemical, and nuclear. Then he presented the basic equations that describe the three rates.

In another paper, Britain's A. J. Young of Imperial Chemical Industries discussed how you might represent process dynamics mathematically. He grouped unit operations according to the form of the integro-differential equations which describe their dynamics. Young offered four generic types: heat exchange, agitation, distillation, and chemical reaction.

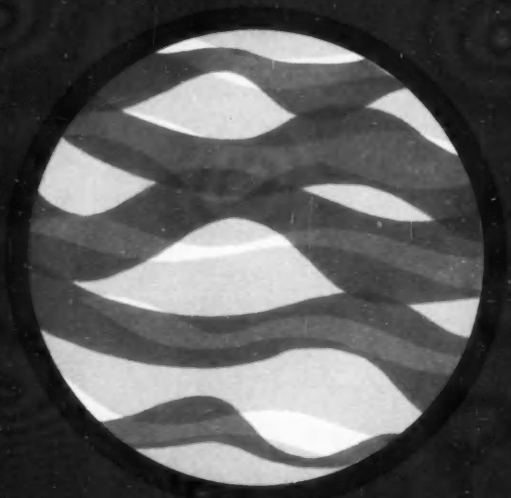
In his prediction of "What's Ahead in Kinetics and Reactions", C. H. Barkelew of Shell Development broke down chemical reactor groups into four sub-classifications: batch, continuous stirred tank, packed flow, and unpacked flow. He cited turbulent flames, jets, and shock tubes as examples of reactors in which dynamics were important.

Apparently none of these speakers

OBSTRUCTIONLESS FLOWMETERING



from a trickle...
to a torrent

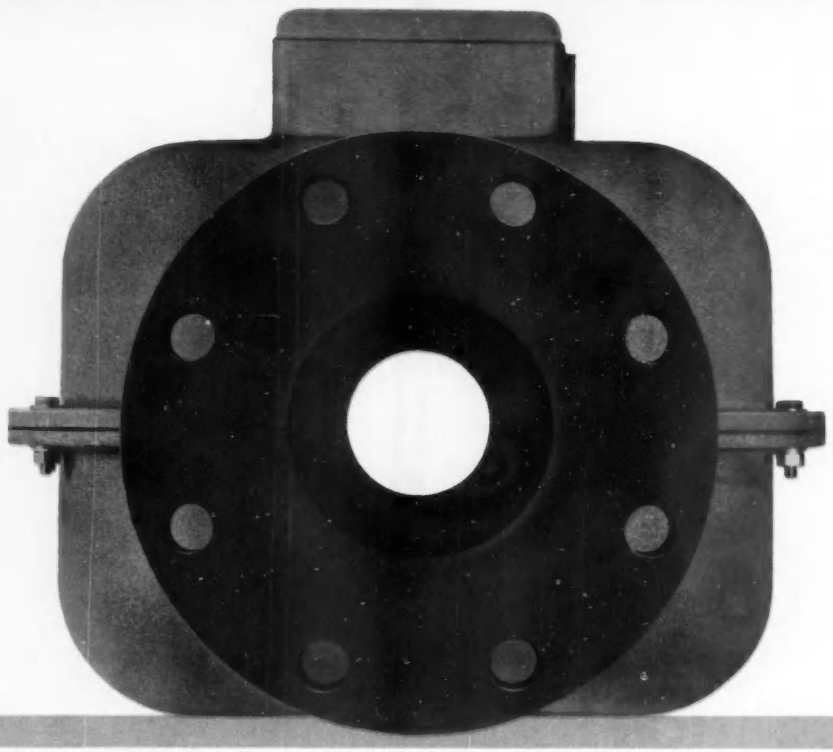


FP



F&P MAGNETIC FLOWMETER

lets you set any flow at full scale . . . from 1 to 30 fps



A turn of a dial gives you full-scale recording for *any* flow rate from 1 to 30 feet per second and permits operation at optimum chart position. This flow range flexibility costs you no more . . . it's an "extra" that's built into every *Fischer & Porter* Magnetic Flowmeter.

If you want to check our claim that F & P gives you more meter for the money, take a good look at these additional exclusives:

- *Any* primary is interchangeable with *any* secondary . . . no custom matching of meter to recorder.
- Remote recording up to 2000 feet from the meter.
- Power requirements substantially reduced . . . 117v, 60 cycle a-c in *all* sizes.
- Can measure reverse flows *without auxiliary equipment.*
- Fast response time . . . 2-3 seconds full scale.
- Adjustable damping of flow signal.

Before you buy *any* magnetic flowmeter, investigate the advantages of F & P's magnetic flowmeter. Get in touch with the F & P field engineer nearest you and write for Catalog 10D1416. Fischer & Porter Company, 698 County Line Road, Hatboro, Pa. In Canada, write Fischer & Porter (Canada) Ltd., 2700 Jane Street, Toronto, Ontario

FP FISCHER & PORTER COMPANY *COMPLETE PROCESS INSTRUMENTATION*

set out to urge a regrouping of unit operations. And none carried the idea out all the way. But the pattern that emerged left a number of control engineers mulling over the desirability of such a change.

• **Using computers**—New process control techniques discussed included Monsanto's T. J. Williams's description of an organization set up to solve problems in automatic operation of chemical plants. Williams said that such an organization had to have extensive analog and digital computing equipment. For simulation purposes, he suggested the following proportions of analog computer components (based on 100 operational amplifiers):

Operational amplifiers	100
Summers	40
Integrators	60
Servomultipliers	20
Diode Function generators	10
Computing consoles	2
Operational relays	12
Pot padding sets	20
Extra problem boards	4

Williams opined that present dynamic testing is not adequate for gathering data necessary to assess potential economic gain of automatic processes with improved performance. A. J. Young pointed out that such an economic evaluation would be essential.

• **Economic discussions**—In a session on economic evaluation, Chaplin Tyler, E. I. du Pont de Nemours & Co., Inc., emphasized that accuracy of estimates during final plant design (when most of the measurement and control equipment is specified) have to improve so that they are within plus and minus 5 percent.

CtE's W. E. Vannah concluded the control sessions with specific examples of applications of measurement and control that have demonstrated first-year earning powers ranging from 3:1 to 15:1. The latter used a closed-loop composition control system.

All Inertial System

Atlas ICBM will get an all inertial guidance system to replace its present radio inertial system. The change results from successful Air Force tests with an American Bosch Arma all inertial system based on a subminiature fluid suspended gyro compass. Arma also uses a transistorized digital computer and accelerometers.



The finest general purpose temperature regulator in the industry. For the first time, you can get premium quality "extras" at no added cost. This new self-powered regulator is trouble-free, powerful and sensitive. Installation is easy and inexpensive. Large Sylphon® Bellows provides perfect stroke action for valves up to 4". Handles pressures up to 250 psi. Designed for extra-long life.

5 new extras at no extra cost:

1. New Teflon Chevron valve stem packing—no sticking, no leaking, no lubrication . . . ever!
2. New Monel Valve Stem—super-finished to prevent sticking!
3. New "Quick-Detach" stem fitting—valve removable without disturbing adjustments!
4. New Design incorperates "MA" valve—for "dead-end" service!
5. New overrun assembly—prevents regulator damage from overheating!

WRITE FOR BULLETIN D-RW

Mr. Controls

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CONTROLS COMPANY

FULTON SYLPHON DIVISION • Knoxville 1, Tenn.

CIRCLE 26 ON READER-SERVICE CARD

← CIRCLE 25 ON READER-SERVICE CARD



Range: −29 to +71°C;
Constancy: ±0.005 to ±0.028°C

Many applications in research and industrial laboratories

The Aminco Wide-Range Laboratory Bath may be used either as a precisely-controlled constant temperature bath, or for circulating controlled-temperature liquids through external apparatus such as condensers and water-jacketed devices. The bath is ideally suited for cooling water for X-ray and other photographic film processing; providing cooling-water for low temperature viscometer tests; etc.

Bath contains both refrigerating and heating elements, i.e., a self-contained, hermetically-sealed refrigeration system utilizing Freon as the refrigerant, and two 500-watt Lo Lag immersion heaters.

Two models are available, (16 and 50 gallon capacities). The bath features an all stainless steel interior, pump casing and motor stirrer, and is provided with a removable perforated, stainless steel shelf. Pump motor, bimetal thermo-regulator, and inlet and outlet connections are mounted on top of the bath.

Also available with the bath is a shaking mechanism which permits agitation of flasks, bottles or test tubes while immersed in bath liquid. This device is entirely self-contained and can be rapidly attached or removed without the use of tools.

Complete information contained in **Catalog 500-P2**

AMINCO **AMERICAN INSTRUMENT CO., INC.**
8030 Georgia Ave., Silver Spring, Maryland

CIRCLE 27 ON READER-SERVICE CARD

WHAT'S NEW

Clinics and Workshops Fill ISA Program

Clinics and workshops, the widest choice ever offered by ISA, will complement the regularly scheduled technical sessions at the 13th Annual Instrument-Automation Conference & Exhibit scheduled for Philadelphia's Convention Hall, Sept. 14-19.

Even before the exhibition and technical sessions get under way on Monday, Sept. 15, a two-day instrumentation clinic will open on Sunday. This clinic will offer registrants a choice of five options, for those interested in pursuing applications in a specific industry. A general course will cover instrument calibration and checking techniques and equipment. The application options then will concentrate on these industries: metals, ceramics, power plant, chemical and petroleum.

A one-day computer clinic will be held on Thursday, Sept. 18. The morning session will cover basic instruction in both analog and digital machines. In the afternoon, there will be two simultaneous sessions: one will cover application of analog devices; the other digital computers.

Other special events scheduled for the Philadelphia meeting:

- Sales engineering workshop, on Sunday afternoon
- Control systems workshop that will review the application of dynamic analysis techniques, on Monday afternoon
- Maintenance management workshop, all day Tuesday
- Data handling workshop, all day Tuesday
- Educators Workshop, starting Wednesday morning.
- A special lecture series on Monday, covering the broad aspects of three areas of instrumentation: 1) process stream analyzers, 2) telemetry, 3) data handling systems.

The regular technical sessions will start with a keynote session on Monday morning, run through the week until Thursday.

Control System Tested

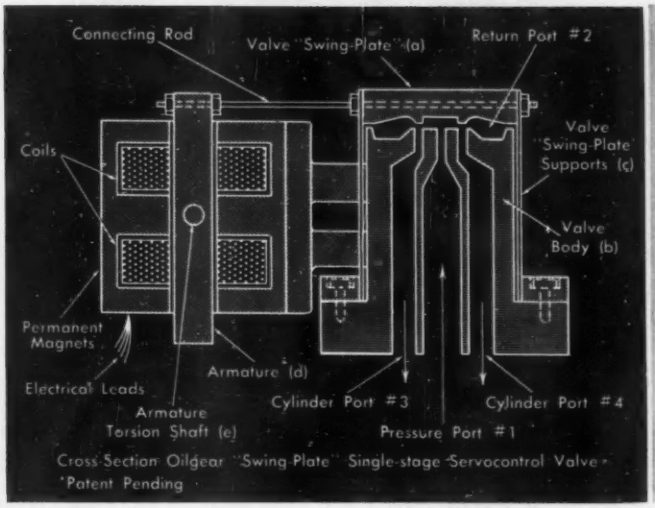
Jet reaction control system for a tactical type vertical take-off and landing plane is being designed by Ryan Aeronautical Co. for the Navy. First component to be tested will be a nozzle which diverts the exhaust stream for pitch and yaw control.

. . . Fluid Power News

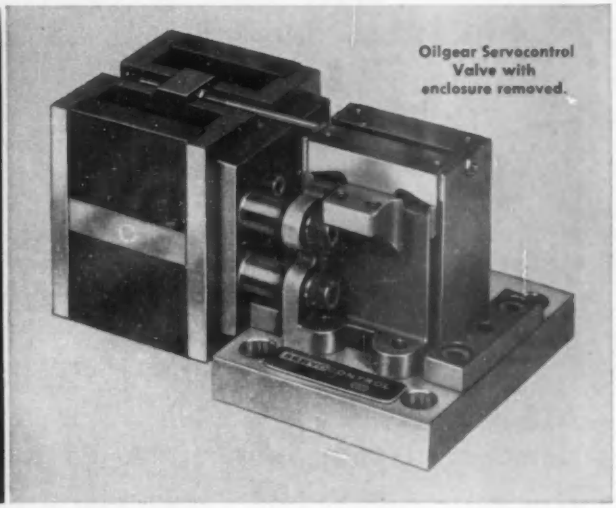
NEW INDUSTRIAL SERVO-CONTROL VALVES

New Oilgear Electrohydraulic Servocontrol Valves*

SERVO VALVE DESIGN OBJECTIVES: 1: Greater control accuracy and resolution for rotation and straight-line drives. 2. For industrial applications, must be capable of controlling wide pressure and volume range with single-stage, fast response to a low input signal. 3. Eliminate conventional valve frictional problems between spools and cylinders. 4. Eliminate two-stage linkage and stability problems. 5. Eliminate first-stage pilot systems — supply pressure, centering devices, filters, and orifices required for pilot systems. 6. Provide a flow rate substantially linear to valve displacement, with stability in null position. 7. Eliminate or substantially reduce valve "dead-band," sticking, jamming, scoring. 8. Be "fail-safe." 9. Operate safely in hazardous locations.



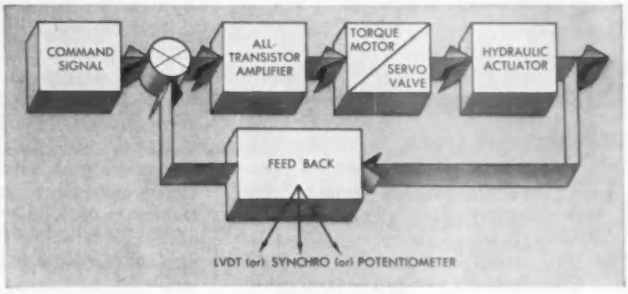
Cross-Section Oilgear "Swing-Plate" Single-stage Servocontrol Valve*
*Patent Pending



SOLUTION: 1. A new concept of three and four-way single-stage electrohydraulic servo valve construction . . . only two moving parts in Oilgear's new "Swing-Plate" design. 2. No metal-to-metal contact between "Swing-Plate" (a) and valve body (b) . . . frictionless for high sensitivity, fast response to minute signals — virtually eliminates sticking, scoring, jamming. 3. Clearances and port seal sizes can be varied to suit application and fluid handled. 4. Sharp, long rectangular chambers and lands linearize valve characteristics — flow rate essentially a linear function of valve displacement . . . supply high fluid power gain with minute "Swing-Plate" movement. 5. Hardened stainless steel construction assures reliable operation well in excess of a hundred million cycles, even with non-lubricating fluids. 6. No pilot system pressure, centering devices, orifices, or internal filters required. 7. Spring-steel supports (c) respond instantly to low torque motor forces. 8. As torque motor armature (d) pivots on torsion shaft (e), valve automatically centers in event of power failure for "fail-safe" operation. 9. For operation above 500 psi, a compensating cap equalizes hydraulic forces to maintain selected clearances. 10. No special modification required for use in hazardous locations. 11. Valves — open or enclosed — can be gasket-mounted. Pipe tap subplates are available.

PERFORMANCE DATA: Flow Rate — 4 gpm at 250 psi; 8 gpm at 1000 psi pressure drop across valve. Supply Pressures — to 3000 psi. Torque Motor; Mid Position Force — 11 lb min.; 5 watts max. power demand; Stroke — 0.015 inches; Hysteresis — less than 3%; Differential Current — 150 ma; Resistance per Coil — 80 ohms. Other coil current and resistance values available. Net Weight — 4¼ lb. Width: 4¾"; Height: 2¾"; Depth: 3".

Oilgear can supply all components for Fluid Power Servocontrol systems . . . all-transistor amplifiers, manual controls, preset controls, two-stage servo valves, variable displacement pumps, variable speed drives, motors and cylinders.



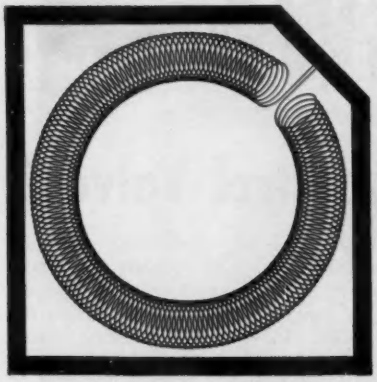
New Oilgear Servocontrol components applied to controls on Oilgear pumps and transmissions provide greater system accuracy and resolution. Functions easily attained with new Oilgear Servocontrol open and closed-loop systems are: 1. Precision, high-response speed control from zero to maximum rpm in either direction through remote control stations or switches. 2. Positive, high response, follow-up position control through remote command units. 3. Output motions or speeds with closed-loop systems will remain near constant with accuracies from 0.1% to 1.5%, and with resolution down to 0.05%.

For further information on these new valves and systems, call your Oilgear Application-Engineer. Or write, stating your specific requirements, directly to . . .

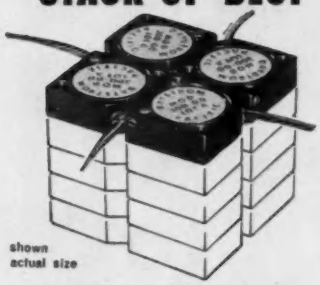
THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

1587 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN



DAYSTROM PACIFIC SQUARETRIMS STACK UP BEST



shown actual size

Daystrom Pacific Squaretrims—subminiature trimming potentiometers— stack up best because of these exclusive and unique features:

EXCLUSIVE SQUARE DESIGN—permits the stacking of as many as twenty 50K pots into one cubic inch

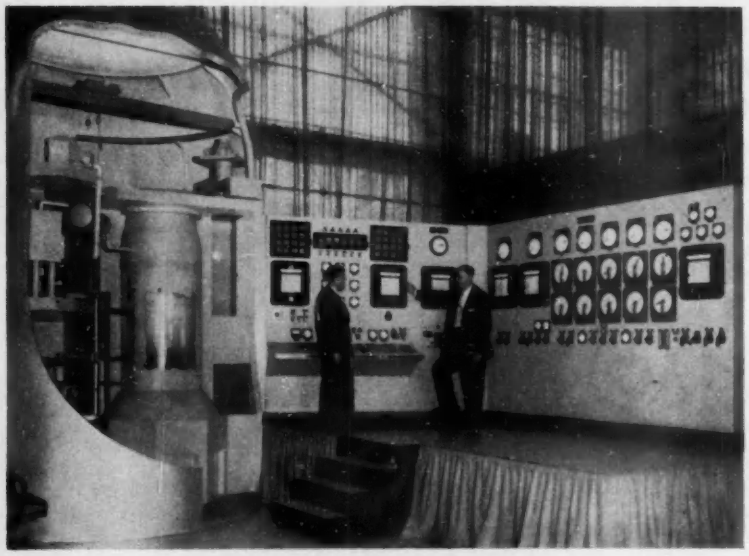
MORE ACCURATE TRIMMING—42 turns for one complete sweep of the wiper—almost one-third more than conventional pots

GREATER STABILITY—exclusive worm gear adjusting device for rugged mechanical stability...unique circular design which eliminates resistance changes due to thermal expansion-contraction effects on the mandrel

For complete specifications, contact the representative in your area...or write the factory direct.

DAYSTROM PACIFIC
a division of DAYSTROM, INC.
9320 LINCOLN BOULEVARD
LOS ANGELES 45, CALIFORNIA

CIRCLE 28 ON READER-SERVICE CARD



Analog computers and model reactor plant combine in a . . .

Realistic Nuclear Trainer

Most realistic nuclear simulator ever built will start training reactor operators this month at the Argonne National Laboratory. Built by Leeds & Northrup Co., the machine uses analog computers and a variety of accessory devices to duplicate exactly the nuclear processes and operation of ANL's experimental boiling water reactor–from creating an artificial blue-green glow characteristic of the Cerenkov effect to bubbling air through a water-filled window which imitates boiling. Engineers have dubbed the unit SOBER (for Simulation of Boiling-water Experimental Reactor).

The simulator, complete with a scale model of the plant itself, was exhibited at the Second International Conference on the Peaceful Uses of Atomic Energy, at Geneva, Switzerland. Later this month, it will be flown back to ANL to fulfill its primary role of training operating personnel from all over the world.

• **Graphic display** – Although the computers and set of full-scale controls would be sufficient for training purposes, the simulator includes a plant model in which operators can watch reactor performance. This graphic display of reactor operation and steam cycle, says L&N engineers, gives the trainees a much clearer conception of the interaction between process and controls.

For example, through a window in the side of the model reactor, a trainee can watch control rods emerge from the pile as the plant is started up. At the same time, he can observe the rise in neutron flux on both the logarithmic and linear recorders.

Simple techniques for the graphic simulation of water level, boiling, and the striking blue-green glow known as the Cerenkov effect further enhance the realistic impression.

• **Graphic simulation**–The window in the side of the reactor actually consists of two curved sheets of plastic located just inside the cutaway area of the reactor wall. Slightly separated, and sealed on both sides and bottom, these sheets form a very shallow tank which, when filled with water, makes it appear as though the entire vessel is filled to that level. A small compressor beneath the tank pumps air through the water, simulating the formation of steam bubbles. Colored lights provide the artificial Cerenkov effect. Indicator lights on the dummy valves in the model's steam piping tell the operator whether the valve is open or closed.

The plant model also shows the

ATTENTION

all aircraft development and maintenance engineers



The Weatherhead Company has on file many case histories verifying the dependability, low cost installation and maintenance advantages of our famous Ermeto MS flareless hydraulic and pneumatic tube fitting. Perhaps no other fitting has contributed so much to the advancement of aircraft piping technology or has attained wider recognition and usage in critical applications.

We know, however, that there are many types of aircraft installations on which we do not have full technical data. Here's your chance to help us compile a broader range of application information — and maybe win a big cash prize for yourself as well.

This is a national contest open to all design, planning and maintenance men with a story to tell on either the Weatherhead Ermeto tube fitting in industrial applications, or the MS flareless fitting in aircraft.

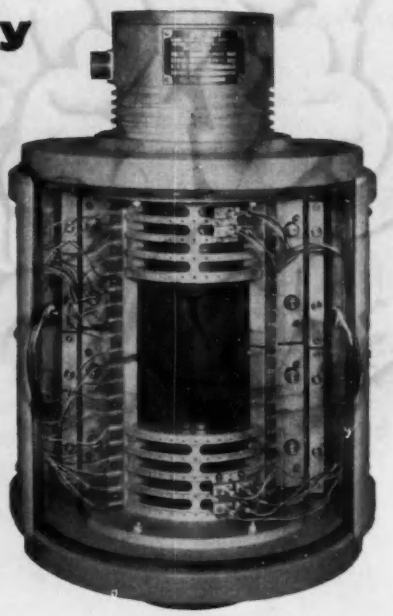
1st Prize . . . $1500.00
2nd Prize . . . $1000.00
Next 8 Winners $750.00
175 Other Cash Prizes

act now . . . contest closes Sept. 30, 1958



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Improve Your Memory



with a standard multiple purpose off-the-shelf drum

The 512-A Bryant general purpose magnetic storage drum meets the exacting requirements of a production component, yet has the versatility necessary for laboratory work. This standard 5" dia. x 12" long drum is stocked for immediate shipment, complete with standard components such as general storage brackets, recirculating register brackets and magnetic read/record heads. Its low price reflects the benefits of Bryant's 25 years' experience in the efficient design and production of high speed precision spindles.

Features:

- Guaranteed accuracy of drum run-out, .00010" T. I. R. or less
- Integral drive—Bryant precision motor (1200 to 12,000 R. P. M.)
- Capacities to 625,000 bits
- Accommodates up to 240 magnetic read/record heads
- High density ground magnetic oxide coating
- Super-precision ball bearing suspension
- Vertical mounting for trouble free operation

Special Models: If your storage requirements cannot be handled by standard units, Bryant will assist you in the design and manufacture of custom-made drums. Speeds from 60 to 120,000 R. P. M. can be attained, with frequencies from 20 C. P. S. to 5 M. C. Sizes can range from 2" to 20" diameter, with storage up to 6,000,000 bits. Units include Bryant-built integral motors with ball or air bearings. Write for Model 512-A booklet, or for special information.



Remember . . . you can't beat a Bryant drum!

BRYANT COMPUTER PRODUCTS DIVISION

BRYANT CHUCKING GRINDER CO.

P. O. Box 620-L, Springfield, Vermont, U.S.A.

CIRCLE 30 ON READER-SERVICE CARD

WHAT'S NEW

. . . automatic generator load control is on simulator; will be added to reactor later this year . . .

turbine blading through a cutaway in the casing. When the light on the turbine supply valve indicates the open position, another drive motor causes the blading to rotate.

• **How it works**—Here's what happens during a typical start up. The operator at the control console (see photo above) starts the control rod drive motors. Slowly, the rods are withdrawn from the core. In an actual reactor, this rod withdrawal permits neutron radiation to bombard the atomic fuel in the core.

At this point, the operator can see the water in the vessel take on the bluish-green glow. Instruments on the control panel begin to record the facts necessary for handling the reactor These readings come directly from the analog computers which are simulating the plant.

As the plant is brought to the "critical" or operating point, the instruments cover the flux level range in eight decades. Instead of a single computer over this entire range, L&N engineers have used two identical computers. After one computer has furnished data covering a single decade, the other takes over and carries the process through the next decade. Meanwhile, the range of the first is changed to cover the third decade. Thus the computers take alternate turns at control until the process reaches the critical point.

As the computers supply information to the control panel on neutron population, rate of energy release, temperature pressure, and other conditions, the operator uses the instrument readings as guides in bringing the model to its simulated proper power level. Should he make a mistake that could damage a real reactor, the computer immediately detects the error and permits the safety features of the instrumentation to automatically take charge until the model is again operating properly. This is exactly what would happen on the real reactor equipment.

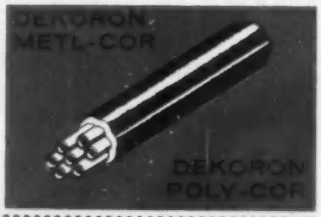
One piece of instrumentation which SOBER has is not found on the actual EBWR. This is automatic generator load control. Developed for EBWR, the automatic control will be installed on the operating reactor later this year.

—Frank X. McPartland

here's how to specify

DEKORON INSTRUMENT HARNESS

to fit your requirements exactly

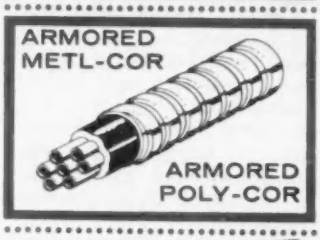
ALUMINUM OR COPPER / POLYETHYLENE OR NYLON + plastic sheath = 

FOR CORROSION RESISTANCE



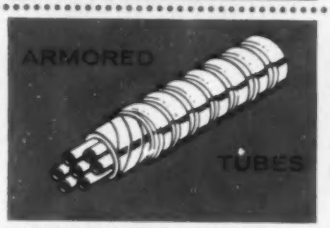
+ steel armor = 

FOR IMPACT AND CORROSION RESISTANCE

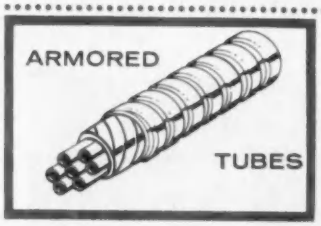


+ plastic sheath = 

FOR IMPACT AND MAXIMUM CORROSION RESISTANCE

ALUMINUM OR COPPER / POLYETHYLENE OR NYLON + insulating tape + steel armor = 

FOR IMPACT RESISTANCE IN DRY LOCATIONS



+ plastic sheath = 

FOR CORROSION AND IMPACT RESISTANCE

No matter what your special environmental requirements for instrument tubing may be—no matter how stringent for corrosion, impact or fire resistance—there's a type of Dekoron instrument line harness to *satisfy them exactly*. In most cases you can get *delivery from stock*. And *all* Dekoron products have three things in common: Highest quality materials and construction . . . lowest possible installation cost . . . longest life of any instrument line harness. That's *Dekoron—America's Premier Instrument Tubing Line.*

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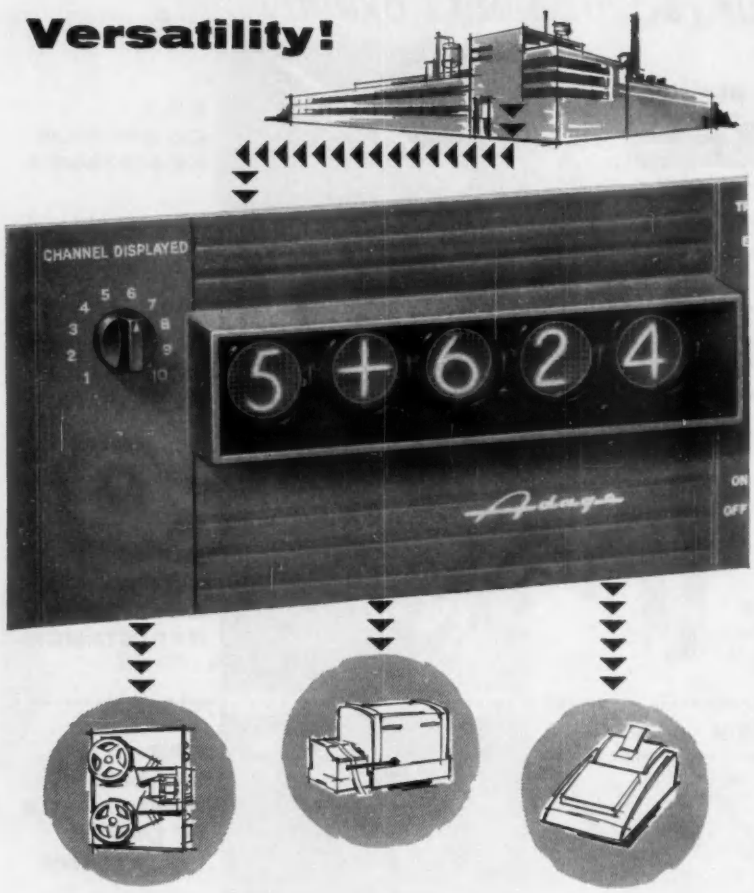
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SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO

CIRCLE 31 ON READER-SERVICE CARD

New Adage Converters Offer Unlimited Versatility!



Unlimited Versatility? — a large statement. But the facts back it up! Voldicon will translate inputs from any source into any storage device.

Name your input: thermocouple, strain gage, telemetry data, analog computer (there are too many possibilities to list here) . . . Name your output: magnetic tape, tape punch, printer, digital computer . . . Voldicon will handle any combination.

Whatever your needs there is a Voldicon model designed to answer your problems . . . well within your budget.

NEW VOLDICON FEATURES:

- **New Transistor Design**
- **New Speed** — up to 10,000 separate conversions per second
- **New Accuracy and Reliability**



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CIRCLE 32 ON READER-SERVICE CARD

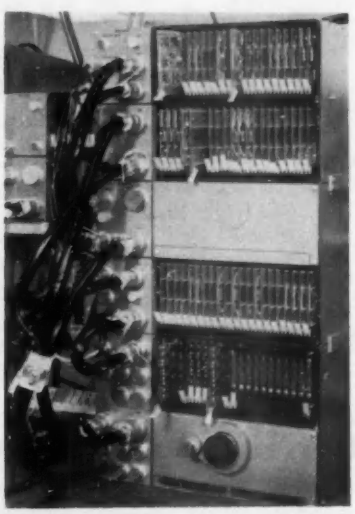
Integrated System Flight Tests DC-8 Jets

Flight Tests of the Douglas Aircraft Company's DC-8 jet engine commercial aircraft will be speeded up by a new integrated data handling system. Built by Consolidated Electrodynamics Corps., Datalab Div., at a cost of $2,250,000, the system samples low-level outputs from a wide variety of transducers at rates up to 50,000 samples per sec, then prepares the data for entry into a digital computer. CEC will supply one complete system and three additional airborne data-acquisition systems.

The high-speed, high-capacity setup is composed of three groups of equipment: an airborne data acquisition system, a ground control record station, and a computer input facility. The ground control station is trailer-mounted; the computer input facility is located at Douglas' plant.

Airborne part of the system accepts signal voltages from analog transducers and digital input devices. Its output is three fold: digital samples recorded on magnetic tape, digital samples transmitted via PCM/fm telemetry, and an analog display of selected transducer signals on a CRT bar chart for the flight test engineer.

One hundred primary channels make up the basic airborne system. One complete scan of the primary channels represents a "frame" of data. The system can sample primary chan-



Airborne system is transistorized and modularized to save space and improve reliability.

YEAR 'ROUND BONUS!

You Get More Than Just a Valve When You Buy BS&B's Super 70

Specification of BS&B Super 70 Diaphragm Control Valves on your next job will assure you of getting all of the following:

1. High Quality Product . . . The BS&B Super 70 Diaphragm Control Valve has high efficiency and stability. In addition to thousands of hydraulic flow tests performed in the laboratory, analysis of operating data gathered from Super 70's on stream in customer plants substantiate their excellent performance.

2. Application Engineering . . . Today's complex processing problems require detailed analysis to determine proper instrumentation and control applications . . . accurate control valve sizing. This is a regular service to Super 70 customers.

3. Start-up Assistance . . . After helping customers select the right valve for a specific job, BS&B follows thru by assisting at plant start-up time.

4. Time-saving Scheduled Maintenance . . . With the patented clamp ring—float ring closure, valve maintenance can be done in a fraction of the time required by conventional type valves . . . an economic must in future valve specifications.



Clamp Ring — Float Ring Closure



Flanged — Gasket Closure

BS&B Super 70 Valves are available in either clamp ring—float ring, sealed bonnet or flanged-gasketed body closures. Whichever type you choose, when they're "on stream" you'll *know* that they're exactly right for the job.

Call your nearest BS&B office or representative now to discuss your present and future valve requirements. Or if you prefer, write for detailed information.

OVER 60 YEARS BS&B ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-ES9

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Kansas City 26, Missouri.

CIRCLE 33 ON READER-SERVICE CARD

T-J spacemaker cylinder

Quality Engineered

to give quality results

with Extras . . .
at No Extra Cost!



You get more—much more—when you specify and use any of T-J's complete line of Spacemaker cylinders. The Spacemaker is engineered to give you better, more accurate, and longer service—offers, exclusively, many extras . . . that are STANDARD, AT NO EXTRA COST!

Designed to eliminate tie-rods, providing greater strength . . . saves space . . . reduces manhours and costs in all push-pull-lift operations. IMMEDIATE SHIPMENT in a wide range of styles and capacities, with 64,000 combinations. Write for Bulletin SM 155-3 with complete engineering details. The Tomkins-Johnson Co., Jackson, Mich.

METAL PISTON ROD SCRAPER . . . Standard at No Extra Cost!

NEW "SUPER" CUSHION FOR AIR . . . Standard at No Extra Cost!

CHROME PLATED CYLINDER BORES AND PISTON RODS . . . Standard at No Extra Cost!

ONE PIECE PISTON . . . Standard at No Extra Cost!

NEW "SELF-ALIGNING" MASTER CUSHION FOR HYDRAULIC USE . . . Standard at No Extra Cost!

NO TIE-RODS TO STRETCH . . . Standard at No Extra Cost!

STREAMLINED DESIGN . . . Oil Pressure to 750 P.S.I.—air to 200 P.S.I. Standard at No Extra Cost!

FORGED SOLID STEEL HEADS . . . Standard at No Extra Cost!

T-J TOMKINS-JOHNSON
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

CIRCLE 34 ON READER-SERVICE CARD

WHAT'S NEW



High density digital recorder packs 1,000 bits per lineal inch on 16 channels. It uses a flangeless reeling system, accommodates up to 8,400 ft of one-mil Mylar tape.

nels at rates of 500, 250, 100 or 50 frames per sec. Each of the primary channels may be subcommutated by 10 to 1 and/or 100 to 1 as desired. Data is packed on the magnetic tape at rates exceeding 1,000 bits per inch.

At the ground control station, the telemetry data is recorded in a variety of ways:

- digital magnetic tape record
- 100 channel analog bar chart display
- direct writing oscillograph recording up to 20 channels
- display of elapsed operating time
- event mark indication
- parity error display (a counter which indicates dropouts and system transmission errors)

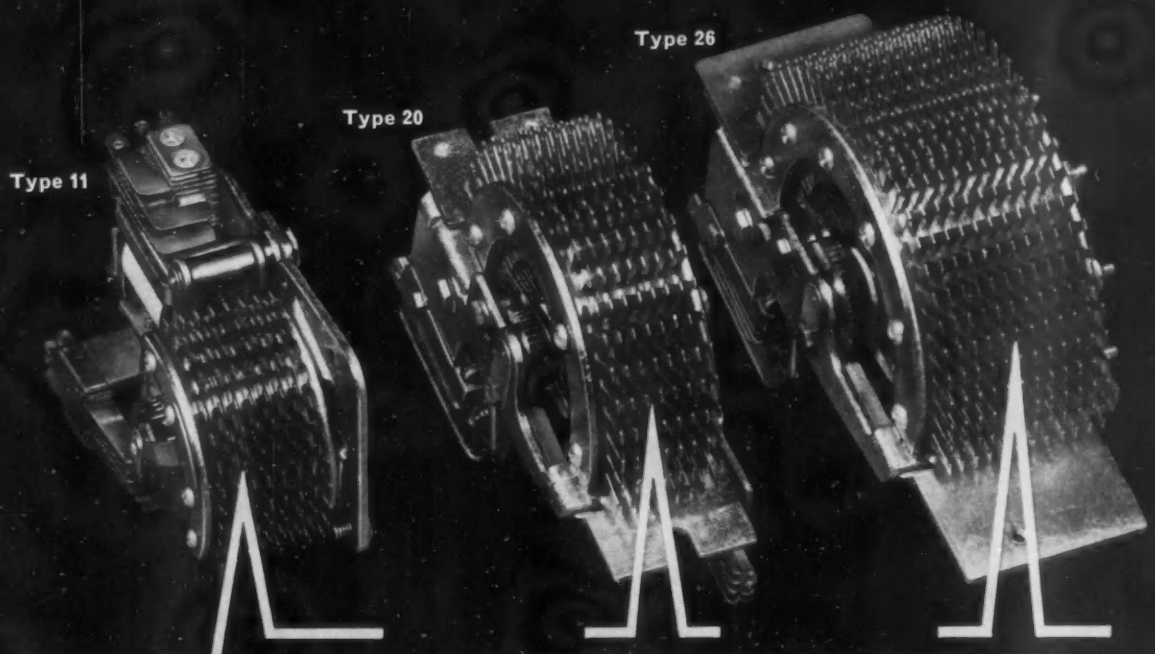
Practically the same outputs (with the exception of event mark indication) are produced at the computer station. An editing control unit selects significant data obtained from the playback of tape records placed on the computer station output tape.

Douglas engineers expect to chalk up big time savings with the new system. For example, a ten sec. structural maneuver performed by a medium bomber normally requires 237-man hours to handle the data; Douglas estimates the new system will reduce this to 58 man-hours.

Perceptron Demonstrates Human Conduct

A non-biological system capable of perceiving, recognizing and identifying its surroundings without any human training or control has been successfully demonstrated at the Cor-

CIRCLE 35 ON READER-SERVICE CARD →



NEW BLUE INSULATION

adds another refinement to CLARE Springdriven Stepping Switches

STANDARD AT NO EXTRA COST

CONSIDER

what these Superior Features will do for YOU !

- ***HIGH INSULATION RESISTANCE***

100,000 megohms minimum between switch points and between each point and frame.

- ***STABLE INSULATION RESISTANCE***

Maintains 100,000 megohms minimum resistance over temperature range from —55°c to +85°c.

- ***LOW MOISTURE ABSORPTION***

Maintains low leakage characteristics in humid environment. Water absorption: 48 hours at 50°c, 0.5% (ASTM Test D570).

- ***GOOD ARC RESISTANCE***

Endures arcing from wiper contacts, maintaining high resistance to dielectric breakdown. Arc resistance: 140 seconds (ASTM Test D495).

- ***MECHANICAL STRENGTH & STABILITY***

High tensile and compression strengths. Holds mechanical dimensions throughout age and temperature variations (vital to retention of stack tightness.) Lifetime shrinkage: approximately .001 in./in.

- ***MEETS MIL SPECIFICATIONS***

MIL—P—14D (Type MDG)
MIL—P—4389 (USAF)

This new Blue Insulation supplied as standard on all CLARE *Springdriven Stepping Switches as soon as present stocks of Bakelite insulators are used up. No extra cost.*

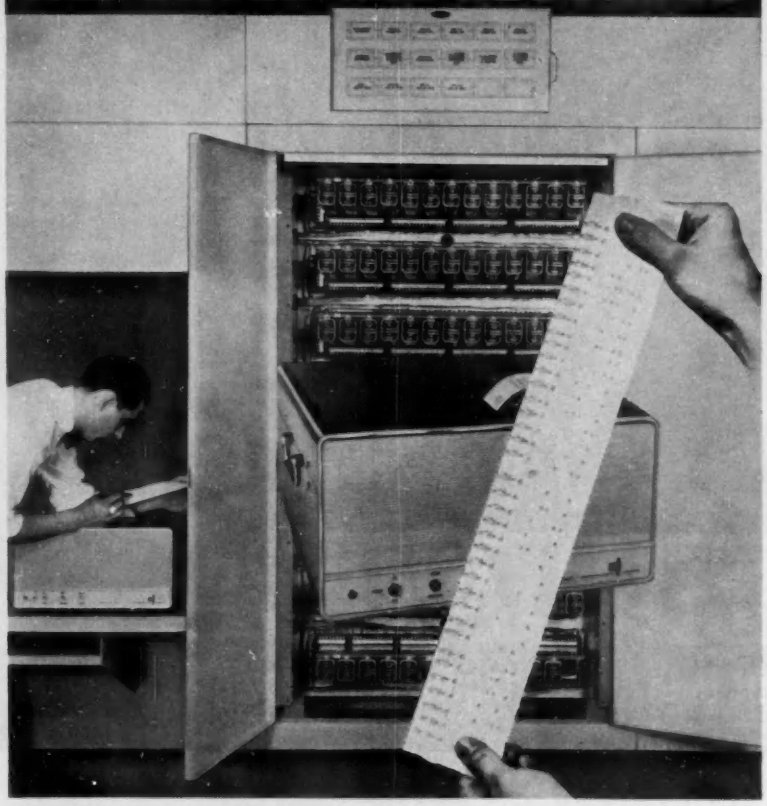
Find out the many other superior qualities of CLARE *Springdriven Stepping Switches. Call or write: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address:* CLARELAY.

Send for CLARE Engineering Bulletin #101

CLARE RELAYS

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NEW PANELLIT RECORDING ANNUNCIATOR UNCOVERS PROFIT LEAKS

- **Pinpoints temperature, flow, pressure and level process trouble areas by accurately, instantly recording off-normal operations.**
- **Permanent, unalterable statistical data helps prevent downtime repetition.**
- **No time-wasting decoding. Directly readable digital form.**

Typical power station application: The exact time period of steam stop valve closure, generator circuit breakers and overspeed trip resets is permanently recorded, providing advance notice of sluggish functioning and permitting immediate preventive action.

Model RA helps attain highest quality products by continuously monitoring all process variables. Also helps reduce downtime, maintenance and operating costs in your plant.

Write for Bulletin 102 today.

PANALARM®

PANELLIT, INC.

7401 No. Hamlin Ave., Skokie, Ill.

CIRCLE 36 ON READER-SERVICE CARD

WHAT'S NEW

nell Aeronautical Laboratory by Dr. Frank Rosenblatt. The "Perceptron" system has been successfully simulated on an IBM 704 computer; a pilot model is still a year away.

According to a Navy announcement, the system had demonstrated the ability not only to "learn" what it is "shown" but also a capability of spontaneously teaching itself to recognize something, and then indicate what the particular something is, even though it had never "seen" it before.

• **Direct recognition** – Preceptron uses direct recognition; it does not recognize items by matching them against a stored inventory of similar images. The association by which a perceived stimulus is identified is derived in the form of new pathways through the system instead of a coded representation of the original stimulus.

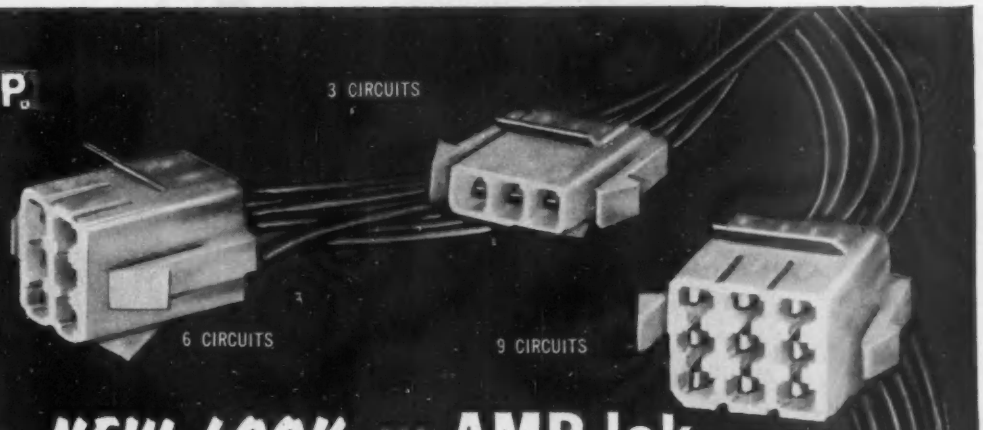
The completed Perceptron model will receive visual images through an optical device, somewhat similar to a TV camera. A mosaic of photocells transform light energy into electrical signals which are carried by cable to an Association System. Composed of many small electronic units, the Association System weakens signals in some channels, strengthens them in others. The connections of the system are largely random, although the general flow of impulses proceeds from the sensory end to the response end.

The effects by which the association system is able to "remember" the preferred connections are primarily statistical. However predicted affects can be observed only in a large number of cells.

• **Differs from a computer**–Dr. Rosenblatt points out that systems which operate on the basis of "statistical separability" are fundamentally different in principle from digital computers, and from control systems which carry out their operations by symbolic logic. The Preceptron, for example, will continue to function even if a large fraction of its association system is destroyed.

First unit to be built will use patch boards to permit flexible inter-connection of units in different ways. Present plans call for an input system of 400 photocells and up to 1,000 association cells. The completed machine should be able to distinguish letters of the alphabet, simple visual forms, and pictures which are dissimilar so that the Perceptron is not confused by their similarity.

AMP

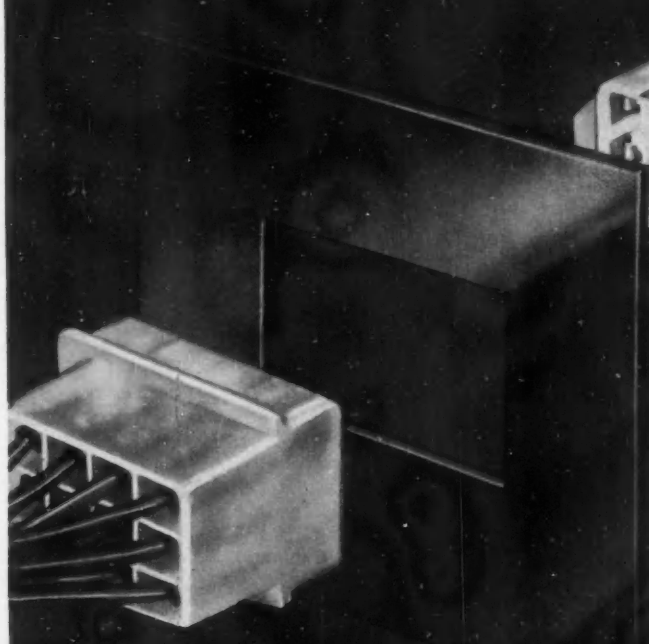


THE *NEW LOOK* IN AMP-lok

Now . . . connect 3, 6, 9 or 12 circuits simultaneously with the AMP-lok multiple connector and a simple push of the fingers.

All units are self-anchoring and require no supplementary mounting parts in through panel multiple connector applications.

AMP-lok can be used as a safe, free-hanging multiple connector also.



AMP-lok obsoletes all it replaces because of the following design features:

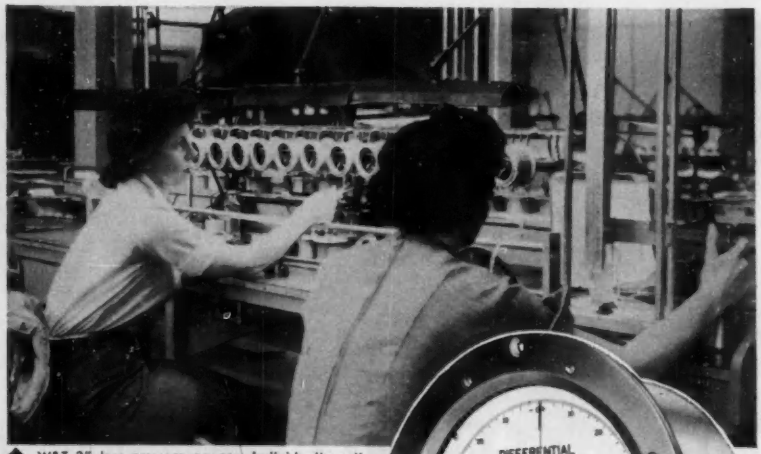
- contacts are identical . . . self cleaning . . . recessed for safety
- finger grip engagement and disengagement
- polarized to eliminate circuit error
- wide panel thickness accommodation—one simple mounting hole required
- color coding available

Additional literature and samples available on request.

AMP INCORPORATED

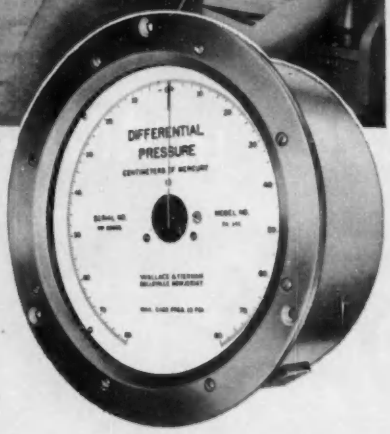
GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

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▲ W&T 3" low pressure gauges, individually calibrated, are checked against a precision standard.

A 6" gauge for easy readout is also available. ▶



PRESSURE MEASUREMENTS WITH PRECISION

W&T low pressure gauges bring 0.3% accuracy, rugged portability to your job

Calibration checked and double-checked . . . so you know the gauge is right when you record a reading. And W&T pressure gauges stay accurate in spite of rough handling. You can use them right on the job—still have laboratory accuracy.

These gauges are in stock now. For information write Dept. A-122.28

service: gauge pressure; differential pressure; vacuum determinations; or as compound pressure-vacuum gauges with zero center; **accuracy:** 1 part in 300; **sensitivity:** 1 part in 500; **minimum range:** 0 to 10 inches H_2O; **maximum range:** 0 to 400 inches H_2O; intermediate ranges of pressure or vacuum in any pressure equivalent are also available.

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

W&T MERCHEN SCALE FEEDERS & METERS

for Automatic Batch Control
Continuous Blending
Materials Accounting

Control the feeding of ingredients by weight to an accuracy of 1%.
Capacities range from 3 to 3000 lbs. per min.

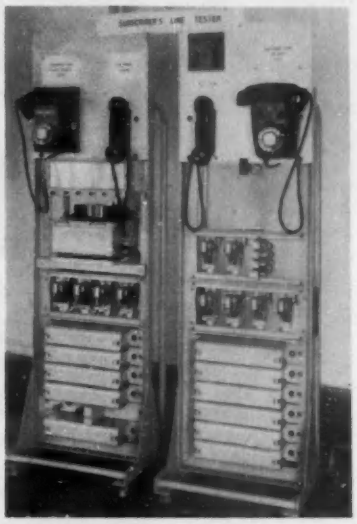
WRITE FOR YOUR COPY OF OUR BULLETIN:
"The Best Weigh is the Merchen Way."

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

M-31.28

CIRCLE 38 ON READER-SERVICE CARD

EUROPEAN REPORT



Automatic line tester speeds installation of phones. Equipment runs through tests, tells field man whether equipment is operating satisfactorily or not.

Automatic 'Phone Testing

In London's telephone network, involving some 1.35 million exchange lines connected to over 2.25 million telephones, fault prevention is easier and cheaper than the cure. Automatic testing of the 2.5 million miles of paper-insulated lead-sheathed cables and of subscribers' installations reduces both time and cost of maintenance.

Three automatic devices have been developed by the London Telecommunications Region, of the General Post Office, to perform tests that previously were time-consuming and had a high fault liability. The aids:

- An automatic call sender which transmits test calls automatically over every route between the testing exchange and other exchanges in the London area.
- A subscribers' line tester which on new installations performs all the necessary installation tests within 15 sec, informing the engineer orally of any faults in the system.
- An automatic line insulation tester which tests 600 lines an hour, printing out the insulation values so that gradual deterioration of cable insulation can be detected.

Locating a fault on the London phone system is almost impossible manually because of the number of

CIRCLE 39 ON READER-SERVICE CARD →





LEADERS IN READOUT AND DISPLAY

Translating the output of data processing systems into a form that is instantaneously absorbed by the human eye and fully understood by the human mind.

S-C **STROMBERG-CARLSON** G-D

A DIVISION OF GENERAL DYNAMICS CORPORATION

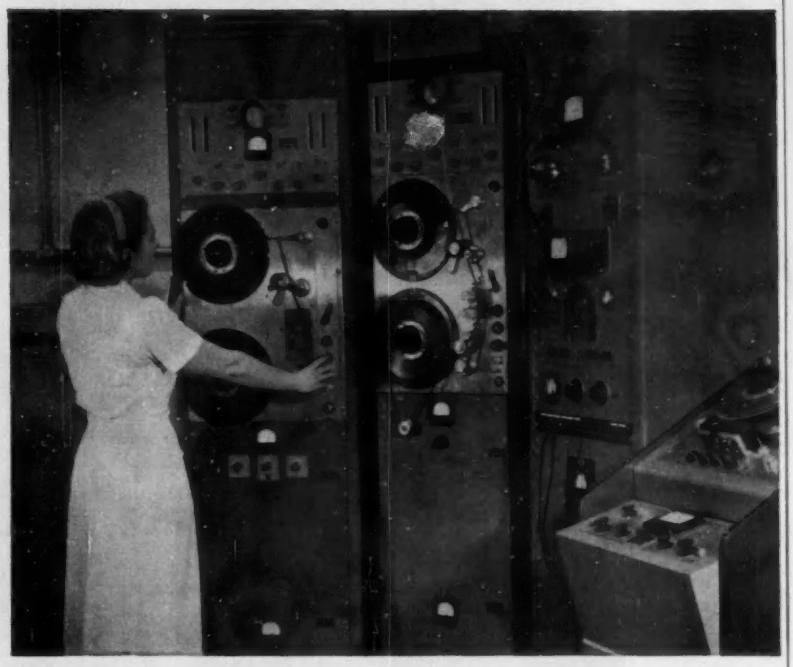
1895 Hancock Street, P.O. Box 2449, San Diego 12, California

"There is nothing finer than a Stromberg-Carlson"



The world's toughest referee

...a count of one and the tape is OUT!



The machine above is a unique testing instrument, designed by Audio Devices engineers and installed at the Audiotape plant in Glenbrook, Conn. This Automatic Defect Counter records and plays back every inch of the EP Audiotape under test.

Type EP is the extra precision magnetic recording tape for applications in computing, automation, telemetering and seismography. If the tape fails to record a single test pulse out of the millions put on a single reel, the entire reel is rejected. There are no ifs, ands or buts.

This is one of many special quality-control operations to which type EP Audiotape is subjected. The extra attention begins at the raw material stage where the master rolls of base materials are critically examined for uniformity of gauge, freedom from stretch, and cleanliness. The oxide and binder components are selected for fineness of dispersion and magnetic properties—then combined and fed through a micronic filter and metered on the seleeted foil in Audio's special dust-free precision coating machines. The coated master rolls are then selected for freedom from imperfections and proceed through the slitting operation. Each ribbon is wiped after slitting to remove all traces of dust, run through the defect counter, rejects discarded, and the defect-free tape packed in hermetically sealed metal cans or plastic cases.

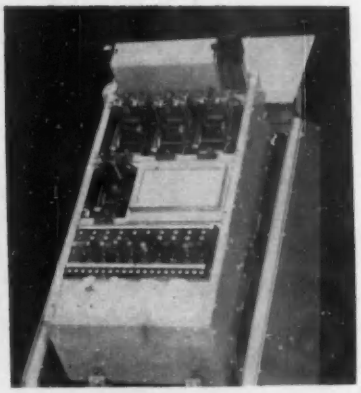
The defect counter does its job so well that type EP Audiotape is *guaranteed* to be defect-free! For more information write for free Bulletin T112A. Write Dept. TC, Audio Devices, Inc., 444 Madison Avenue, New York 22, N. Y.

type EP (EXTRA PRECISION) audiotape (TRADE MARK)

AUDIO DEVICES, INC.,
444 Madison Ave., N. Y. 22, N. Y.

Export Dept.: 13 East 40th St., N. Y., 16 • Cables "ARLAB" • In Hollywood: 840 N. Fairfax Ave.
In Chicago: 5428 Milwaukee Ave. • Rectifier Division: 620 E. Dyer Rd., Santa Ana, Calif.

CIRCLE 40 ON READER-SERVICE CARD



Automatic call sender hunts for faults on routes between 291 telephone exchanges.

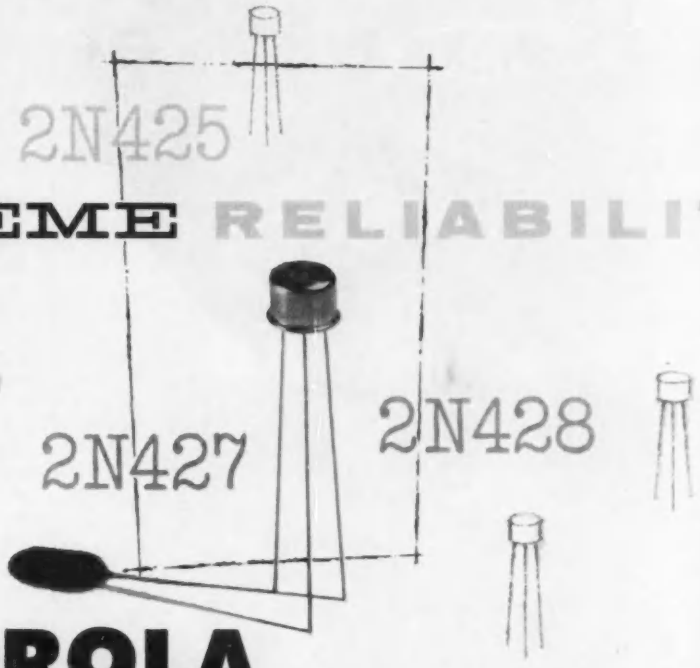
possible routes between the 291 telephone exchanges in the London area. The call may fail at any one of the junction points. And it may not be able to be held long enough to check the particular combination of routes.

The GPO's new automatic call sender pulses out preset numbers over spare calling equipment in the exchange, calling up the test positions of the distant exchanges. The selection is arranged so that every route to every exchange is tested. That means selecting up to a hundred test numbers, pulsing them over 50 calling equipments. In a complete testing cycle each number is sent over every calling equipment.

A 1,000-cps tone is transmitted back to the tester from each distant exchange. In some cases, where a tone is not available at these exchanges, the line is metered for continuity. If no metering condition is received or the tone is more than 18 db down, an alarm is operated and the faulty set of connections held until rectified. After rectification the tester continues to make its programmed calls to other exchanges.

• **Installation help**—The subscribers' line tester has been designed to speed up the routine installation and maintenance work on a subscriber's equipment. Five tests are performed automatically and verbal announcements on each are given to the field staff.

By dialing a three-digit code number followed by the subscriber's number, the field engineer is connected to the tester. If the test equipment is busy, a recording on one of the 12 tracks of a 7-in. magnetic drum informs him, "Wait for tester". When the equipment is ready, the call is connected and the announcement,

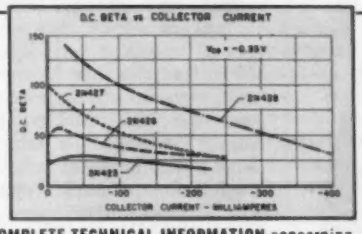


EXTREME RELIABILITY!

MOTOROLA COMPUTER TRANSISTORS

TECHNICAL DATA					
TYPE NUMBER	V_{CB} volts	V_{EB} volts	V_{CE} volts	f_{ab} min mc	h_{FE} typ.
2N425	—30	—20	—20	2.5	30
2N426	—30	—20	—18	3.0	40
2N427	—30	—20	—15	5.0	55
2N428	—30	—20	—12	10.0	80

Collector dissipation in free air: 150 mw
Derate 2.5 mw /°C above 25°C



- High reliability and stability assured by Motorola's advanced production methods and by rigid control of electrical parameters.
- Meet or exceed mechanical and environmental requirements of MIL-T-19500A.
- TO-9 package, hermetically sealed.
- Improved Beta vs Current characteristics.
- Temperature range —65°C to +85°C.
- Special selections to customer specifications are available.

FOR COMPLETE TECHNICAL INFORMATION concerning 2N425-428 switching transistors, contact the nearest Motorola regional office; or wire, write, or phone:

Motorola, Inc., 5005 East McDowell Road, Phoenix, Ariz.
BRidge 5-4411. Teletype PX 80

"DEPENDABLE QUALITY - IN QUANTITY"

MOTOROLA SEMICONDUCTORS

MOTOROLA, INC.
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PHOENIX, ARIZONA

REGIONAL OFFICES

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ESterbrook 9-5200

RIDGEFIELD, NEW JERSEY
540 Bergen Boulevard
WHitney 5-7500

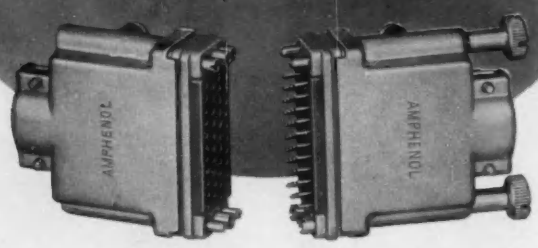
HOLLYWOOD 28, CALIFORNIA
6555 Sunset Boulevard
HOllywood 5-3250

CIRCLE 41 ON READER-SERVICE CARD

2 new

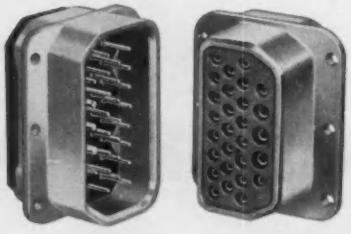
AMPHENOL

RACK & PANEL Series



93 SERIES

94 SERIES



both with POKE-HOME*contacts!

*U. S. PATENT 2,419,018

Meet 2 new additions to AMPHENOL's line of Rack & Panel connectors! The 93 and 94 Series are complete lines of standard connectors providing wide application variety. Both incorporate AMPHENOL's remarkable Poke-Home contacts that are wired separately from the connector then poked home for assembly. Poke-Home contacts are also removable for fast circuit changes or corrections.

93 SERIES 3 insert arrangements, 8 varieties of housings; 500 volts D.C. at sea level; 7½ amp size 20 contacts. Silicone rubber face gaskets. Operating temperature of 400°F. per MIL-C-5384.

94 SERIES 5 insert arrangements in 3 shell sizes; coaxial connectors in 2 inserts; 600 volts RMS at sea level; forged aluminum shells; temperature range of −76°F. to +257°F.

AMPHENOL

chicago 50, illinois

AMPHENOL ELECTRONICS CORPORATION

WHAT'S NEW

"Start test", is given. The field engineer replaces the handset and the tester commences its test cycle.

The first step discriminates between an exclusive and a party line. After this, the insulation resistance of the line to the subscriber is checked under all possible combinations of line-to-earth and line-to-line conditions. If this is satisfactory, a ringing current is sent down the line. If the field engineer does not hear the bell within 5 sec of the start of the test, he lifts the handset to hear the tester report the insulation or bell faults.

When the bell rings, the engineer proceeds to the next test by lifting the receiver, knowing that the equipment is functioning correctly up to this stage. The tester then checks the loop resistance, informing the engineer if this is within limits, and checks the dialing pulses and speed by dialing the number 130.

The whole test cycle takes only 15 sec. On completion, a code number dialed from the subscriber's installation releases the test equipment at the exchange, transfers the line either into service or to the test desk.

Parametrons Figure in Japan's Computer Plans

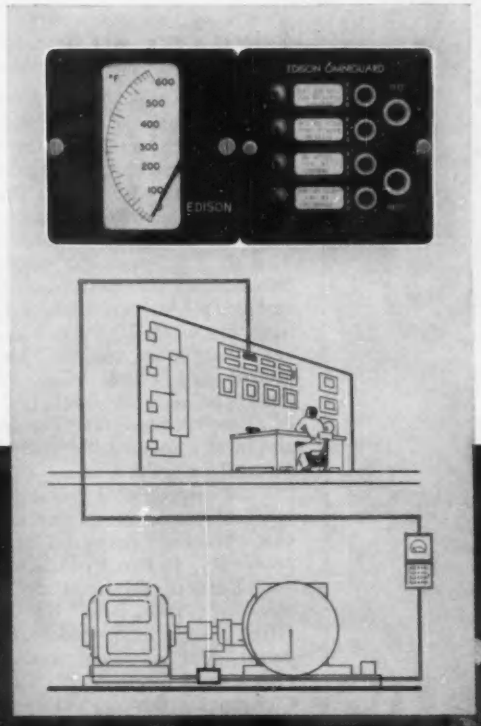
After a slow technological beginning, Japanese computer manufacturers are set to tackle the world-wide computer market. Companies here are optimistic about their chances of capturing a big share of the digital business. They feel the use of parametrons (magnetic toroids with a resistor and a capacitor) instead of vacuum tubes or transistors will give them an economic edge in price and ease of maintenance.

Japanese digital computer business got off to a slow start. It wasn't until 1955 that the first Japanese-designed unit was available commercially. That was the FACOM-128 (Fuji Automatic Computer), a relay computer with a floating point system, built by Fuji Communication Apparatus Mfg. Co. Its arithmetic speed was 0.15-0.20 millisecs for addition; 0.15-0.30 millisecs for multiplication.

Fuji Photo Optical Co., Ltd., built the first electronic digital computer (FUJIC) in March 1956. FUJIC is binary; its word length is 32 bits; its memory capacity 255 words; and its arithmetic speed is 1.6 millisec.

Tokyo Electrical Works (Toshiba),

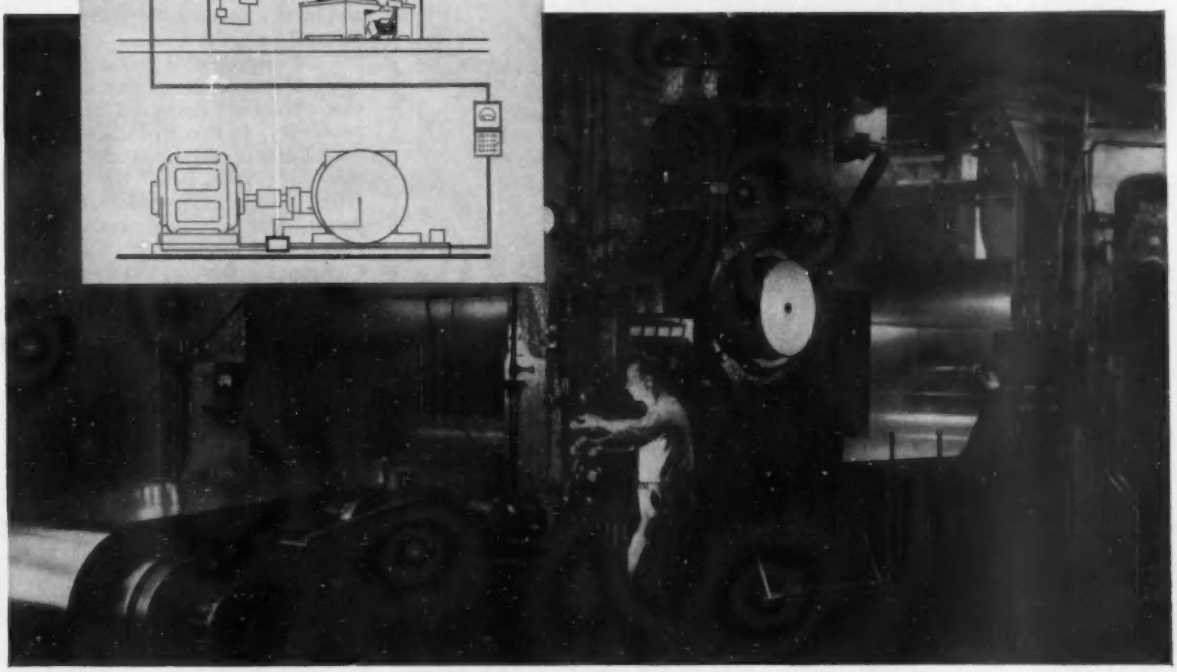
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THOMAS A.

EDISON

omniguard system provides low cost temperature monitoring



Edison Omniguard is the simplest and most flexible monitoring system devised for protection against excessive bearing temperatures, gases and liquids. In an Omniguard installation, plug-in monitor units are grouped according to individual requirements—can be added, removed or switched to other equipment without disturbing the system. Individual alarm settings on each point can be changed at any time without special tools.

This kind of flexibility pays off in reducing installation costs by 50% or more . . . permits purchase of minimum number of units needed at any one time . . . and the addition of more points as new equipment is installed.

Other exclusive Omniguard advantages: Single indicator serves multiple points • each circuit is 'on guard' at all times • no moving parts, nothing to wear out • alarm positively identifies trouble point.

Edison Resistance Temperature Detectors coupled with automatic monitors are low cost insurance against loss of production time, equipment replacement and costly repair charges.

Typical Omniguard Panel shows group of monitor units with their alarm lights, test buttons, and temperature read-out switches. Additional units can be installed in a variety of ways to suit your individual needs.

For additional information on the Edison Omniguard, write for Bulletin 3036B.

Thomas A. Edison Industries

INSTRUMENT DIVISION

38 LAKESIDE AVENUE, WEST ORANGE, N. J.

McGRAW EDISON

CIRCLE 43 ON READER-SERVICE CARD

throw away...

your pencils

your log sheets

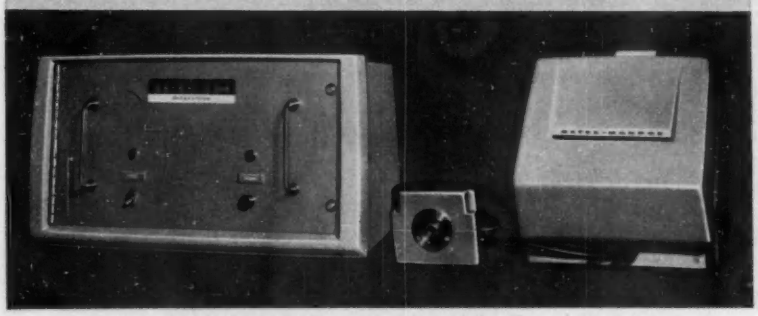
your strip charts



REDUCE COSTS
by using a...

DIGITAL RECORDING SYSTEM $1350

IMMEDIATE DELIVERY COMPLETE



Eliminate Tedious and Erroneous Manual Logging of Recorder Readings... Transcribing Strip or Circular Chart Recordings

- Accuracy: ±0.1%
- Range: 000 to 999
- Speed: 2 readings/sec
- Complete with mounting hardware... ready to operate.

The DATEX K-120 Digital Recording System provides **fully automatic or on demand** digital recording on adding machine tape from self-balancing potentiometers, strip chart recorders, or shaft input. The K-120, consisting of hollow-shaft type shaft position-to-digital encoder, a control chassis, and a DATEX-MONROE printer*, is supplied as a ready-to-operate unit, complete with interconnections and hardware. Normal installation takes less than an hour.

Designed to operate with many types of recorders made by L & N, Bristol, and Honeywell... provides readout of position information from any shaft input. No gearing necessary between the encoder and instrument drive. The encoder will not affect the performance, response, or accuracy of the recorder. Over 100 encoder disc-patterns available. Translates shaft position up to 3 decimal digits (0-999), and provides a large number of non-linear calibrations for CuCn, I-C, and CrAl thermocouples.

*The K-120 utilizes the new DATEX-MONROE printer—first year's service and maintenance provided at no extra charge by your local Monroe office.

Write for full detailed information to...

A SUBSIDIARY OF G. M. GIANNINI & CO. INCORPORATED

DATEX CORPORATION

1307 S. MYRTLE AVENUE • MONROVIA, CALIFORNIA • ELLIOTT 9-5381

CIRCLE 44 ON READER-SERVICE CARD

WHAT'S NEW

a manufacturer of household appliances, recently decided to try its hand in the computer field. Toshiba has been working with Tokyo University on a $300,000 machine called TAC (Toshiba Automatic Computer). The 12-digit TAC uses the decimal system, has two storage systems—an inner storage of 1,000 word length by magnetic drum, or 2,000-word length by core matrix; an external storage of 30,000-word length using magnetic tape. The machine should be finished in a couple of months. The company also owns a share of the newly formed Japan Remington Univac.

That represented most of the Japanese computer activity until this year when the Parametron leaped into popularity. In January Hitachi Works —a builder of ships and electric motors—diversified, built the HIPAC (Hitachi Parametron Automatic Computer). HIPAC has a binary system with a word length of 32 bits. It has a magnetic drum memory with a 1,024 word capacity. And it operates at an arithmetic speed of 8 millisecs.

Two other companies have started making Parametron computers too. The Electrical Communication Laboratory of the Nippon Telephone and Telegraph Company has built a big, pure binary, digital computer, the M-1. NTT estimates that the cost of this machine is only one tenth the cost of a similar machine that used vacuum tubes. Using 5,000 parametrons, the machine uses one-third as much electric power as an equivalent vacuum tube machine. Word length is 40 bits; the machine's core memory has a capacity of 256 words.

Nippon Electrical Communication Company (Nichiden) now has built two parametron computers, smaller in size than NTT's M-1.

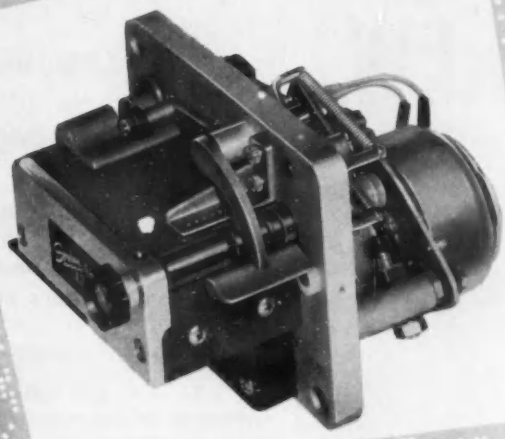
None of these companies has had any technical tieup with foreign firms. But they have been helped along by the Government Electrotechnical Laboratory, headed by Dr. Shigeru Takahaski.

The budding Japanese computer industry may present some headaches for U.S. computer manufacturers. IBM of Japan for example, has its own assembly plant in Japan. Remington-Rand, Daiichi Bussan Trading Company and Toshiba have just formed a 100 million Yen joint company named Japan Remington Univac. The new company will rent, sell and service Rem-Rand computers; later will build such machines in Japan.

—Sol Sanders
McGraw-Hill World News

CIRCLE 45 ON READER-SERVICE CARD →

Now, plug-in tape readers. Reliable rugged, compact SOLENOID and CLUTCH READERS for use with 5, 6, 7, 8, or 16 hole tapes. During reading, solenoid driven readers close reading contacts during the solenoid energized stroke and contacts remain closed until the drive solenoid is de-energized. Tape advance occurs during the solenoid de-energize stroke thereby allowing the function of tape reading to be interlocked with external circuitry. Solenoid readers are ideally suited for applications requiring a maximum reading rate no greater than 20 codes per second. Tests verify a tape life expectancy in excess of 2,000 passes of common paper tapes. Where longer tape life, continuous information transfer, or greater speeds are required, Soroban Clutch Readers are the answer.

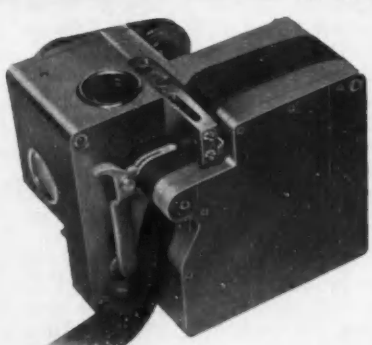


THE DIFFERENCE in Punch Tape Handling is at SOROBAN . . .

Less Maintenance • Less Specilization
Less Operator Fatigue
More Speed • More Reliability
More Flexibility



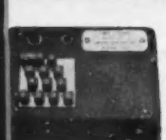
Simple and reliable custom-built TAPE PREPARATION, reproduction, and verification equipments. Equipments tailored to specific needs can be provided for operation with standard 5, 6, 7 and 8 hole narrow tape, or 16 hole wide tapes. All make use of the flexible Soroban Automatic Coding Keyboard which can be supplied with almost any desired coding and keyboard key configuration.



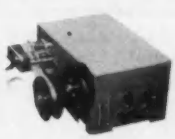
18,000 code groups or 162,000 punched holes per minute. Impossible? Not with the Soroban SUPER-SPEED TAPE PERFORATORS, the first punch tape recorders designed specifically for instrumentation and digital computer output-data recording. These equipments record standard 5, 6, 7, or 8 hole patterns reliably at controlled rates of up to 300 codes per second; 3,000 words per minute.



Data logging and tabulation is simpler with the Soroban COMPUTERITER. Current designs permit both tabulation from electrical inputs as well as production of coded electrical outputs from manual keyboard key entries.



Coding Keyboards



Tape Comparators



Tape Reader Panels



Tape Spoolers

Soroban ENGINEERING, INC.
BOX 1717 MELBOURNE, FLORIDA

NEW



AVION

fast response
servo amplifier

transistor-magnetic
small size • light weight
"built in" stabilization

Suitable for use where specifications for low-power instrument servos call for small size, high gain, and high performance.

SPECIFICATIONS —	MODEL A	MODEL B
Rated Power Output: 3.5 watts, 57 volts Mark XIV motor or equivalent	X	X
Input Impedance: 30K ohm	X	
500K ohm		X
Voltage Gain: 2000 max.	X	
900 max.		X
adjustable by external resistor over 50:1 range		
Response Time: 1 cycle of supply frequency	X	X
Zero drift over ambient Temperature Range (—55°C +100°C): Less than ±5% of rated output voltage	X	X
Inherent servo stabilization at velocity constant of 100-200	X	X
Power Supply: 115 Volts ± 10%, 400 cps ± 5%	X	X

Send for Literature

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CIRCLE 46 ON READER-SERVICE CARD

AROUND THE BUSINESS LOOP

Instrument Sales Bright; So Are Company Outlooks

Dept. of Commerce group expects purchases of control components to pace business, reach $1.5 billion by year's end.

Laboratory and industrial instrument sales in the second half of this year will rise to $1.5 billion, a point comparable to the one they reached in the same part of 1957, says a group of Dept. of Commerce observers. What is more, a rate of growth of these instruments, sparked by increases in range, precision, application, and reliability, will continue far ahead of the rest of the economy.

This is not only highly significant and encouraging, but it is just part of the story. The other part, the word of a prominent British instrument maker, is that U. S. imports of scientific instruments (and therefore the money to buy the same) will start to go up in the same period, and continue up for the next few years.

• **Well out in front**—The group in the Commerce Dept., whose activities have been reported in CtE before, goes by the very long name of the Scientific, Motion Picture & Photographic Products Div. of the Business & Defense Services Administration. Its latest forecast, like most of its others, is based on factors influencing instrument sales (changes in outlays for R&D, the aircraft and missile programs, developments in related fields), and on the relative importance of each user industry to the instrument industry.

Put together, these factors indicate an increase in instrument sales of 12 percent above the $1.3 billion estimated for the first half of 1958. That, says the Commerce group (without mentioning the recession at all), reflects an average annual growth of approximately 15 percent, or about five times the growth of the economy as a whole.

The contribution from Great Britain comes from John Bailey, managing director of Baird & Tatlock, Ltd., of London, one of Britain's largest instrument manufacturers. England and West Germany, says Bailey, are probably ahead of the U. S. in the engineering of special instruments; but

(Continued on page 58)

Tone in annual reports changes for the better; firms now feel they can talk about the recession as though it is something in the past.

"We have weathered the recession in remarkably good shape. No one was laid off, although overtime has been eliminated and for a few weeks we ran short hours. We now have returned to a 40-hour week and new bookings are on an upward trend, matching our production capacity. Our combined backlog is over $1 million, or approximately two months' normal production."

That was the way Horace D. Gilbert, president of Miniature Precision Bearings, Inc., summed things up in his annual report to the MPB stockholders. The report was not included in the general CtE roundup in May (page 52) because MPB is one of a group of companies in the control field whose fiscal years close later than most. Ordinarily just a bookkeeper's preference, this year the late closing took on special importance.

What the presidents of the larger group of companies told their stockholders were hard-to-swallow facts, not mixed with much encouragement. A few months later came reports from the second group, of which MPB is one. In the interim, something very pleasant seemed to have happened to the economy. Things were still far from rosy, but they were yielding to stronger, healthier pressures. Some other examples:

• **Stronger position**—"The year just concluded brought several major shifts in governmental policy which required adjustments on our part to the changing conditions. Yet we feel the company is emerging from this difficult period on a firmer foundation than before" (J. Randolph Richards to stockholders of Automation Instruments, Inc.).

"In looking back over the year, the events do not fall into proper perspective unless they are reviewed in light of the general business outlook, as well as the trends in the electrical-electronics industry. There is every indication that the current decline in our economy is only short-term, and

(Continued on page 244)

New VICKERS® Electro-Hydraulic Servo Valve

has numerous advantages for industrial use:

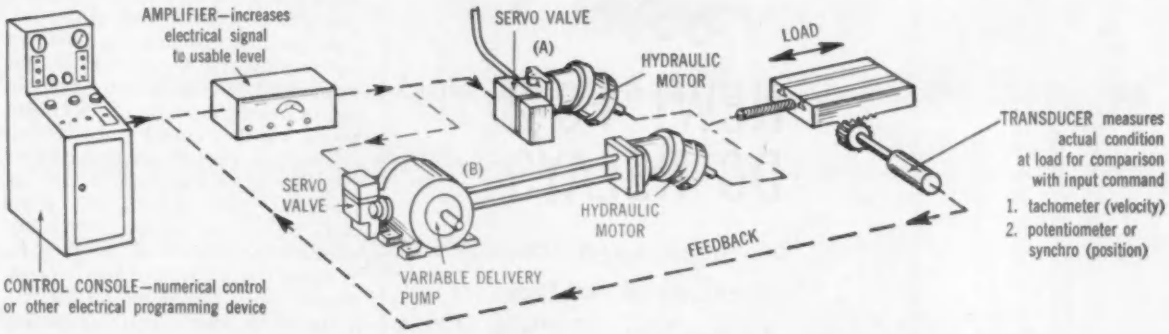
- ***Extremely Accurate***
- ***Simple • Rugged • Dependable***



Vickers Electro-Hydraulic Servo Valve integrated with piston type hydraulic motor provides a minimum amount of oil under compression. Integral cross line relief valves are provided as well as variable cross line orifice for controlling viscose damping. This "package" can provide approximately 20 hp @ 3000 psi and 3600 rpm; variable speed of motor is 0-4400 rpm.

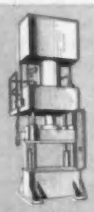
This valve provides a simple, dependable means of translating control signals from electronic programming into extremely accurate modulated flow of hydraulic power for fast and precise closed loop control of position, velocity and acceleration. Performance has been proven on machine tools, industrial processing equipment and ground ordnance applications.

Simplicity and reliability are exceptional . . . only four moving parts are required. Mechanical feedback linkage with unique variable fulcrum provides optimum flexibility for various conditions of flow, response and pressure. For further information, write for Vickers Engineering Bulletin 58-74.

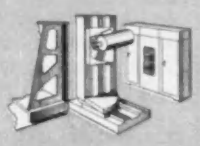


Now the flexibility of electronic control can easily be applied to versatile hydraulic power. Vickers new industrial electro-hydraulic servo valve is used (A) to directly regulate the oil to an actuator (valve motor system). Shown in blue is an alternate application (B) for higher flows when the valve controls a variable volume pump (servo pump system).

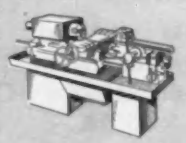
REPRESENTATIVE SERVO VALVE APPLICATIONS



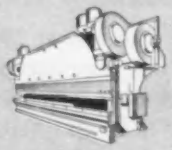
PRESS
Ram velocity controlled accurately during all cycles.



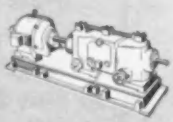
MILLING MACHINE
Precision control of velocity, position and acceleration of slides and tables.



LATHE
Exact feed rate and position control of cutting tool.



PRESS BRAKE
Cylinders synchronized precisely.



VARIABLE SPEED DRIVE
Accurate velocity control of spindle speeds for test stands or machine tools.



PROCESS LINE
Programmed control of Material Handling and machine sequencing.

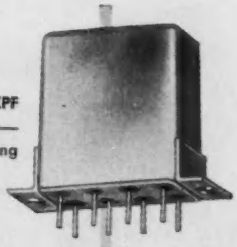
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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

CIRCLE 47 ON READER-SERVICE CARD



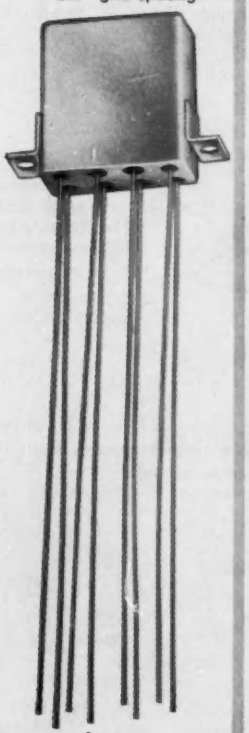
FC-2-XPF
Short leads—
0.2" grid spacing

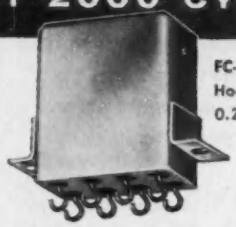
Actual size photos

✓125° C. Ambient...
✓Power and Low Level Switching

✓30 G Vibration
AT 2000 CYCLES

FC-2-XLF
Long leads—
0.2" grid spacing





FC-2-XHF
Hook leads—
0.2" grid spacing

NEW! FC-2 DC RELAYS

Subminiature, hermetically-sealed types

These new FC-2 types are the latest development in high reliability missile relays — designed and produced by Struthers-Dunn, the pioneers in miniature, hermetically-sealed relays.

30 G vibration at 2000 cycles and 50 G shock specifications are readily met, as well as other requirements of MIL-R-5757C and MIL-R-25018.

Write for Struthers-Dunn DATA BULLETIN FC-2

S-D **STRUTHERS-DUNN, Inc.**
Pitman, N. J.

Makers of the world's largest assortment of relay types

Sales Engineering Offices in: Atlanta • Boston • Buffalo • Chicago • Cincinnati Cleveland • Dallas • Dayton • Detroit • Kansas City • Los Angeles • Montreal • New Orleans • New York • Pittsburgh • St. Louis • San Francisco • Seattle • Toronto

CIRCLE 48 ON READER-SERVICE CARD

WHAT'S NEW

(*Continued from page 56*)

the U. S. is way out in front in the application of the concept of automation. To Europe, this differential means just one thing: a bigger American market.

This fall, says Bailey, Baird & Tatlock will introduce to the U. S. market some new instrument systems for automating chemical laboratory analyses. Together, the systems are called Analmatic; they are said to be able to measure a liquid sample, mix it with other chemicals, then make such tests as color or acidity-alkalinity.

Spreading the Analog Gospel

To spread the gospel of analog computing, put the newest analog machines into the field at a faster rate, and encourage turnover of older equipment, Mid-Century Instrumatic Corp. has inaugurated an unusual marketing policy based on the trade-in discount principle. The program has these two not very limiting terms: eligible older machines must have been made by one of five analog computer manufacturers, and they must be rebuildable.

The five manufacturers—Mid-Century, Beckman, Electronic Associates, Goodyear, and Reeves—just about carry the analog computer industry, so that this feature of the program will not pose much of a problem to an interested user. Depending on the condition of his present machine, he can save up to 50 percent of the purchase price of a new one by making a trade. Whatever price is agreed on can be paid in cash or by way of a lease.

• **How it will work**—Mid-Century will take on all reconditioning chores itself, and the cost for doing this work will be reflected in the lease arrangement with the new user. This lease will be based on two-thirds of the discount allowed the original user, plus the cost of revamping. This means, for example, that a $100,000 machine on which the maximum discount of $50,000 has been allowed will rent for $33,000 (two-thirds of $50,000) plus the reconditioning cost.

The new or potential user, the company that has never applied analog techniques before, is an important target at Mid-Century. Said President Robert K. Stern: "Merchandising analog computers to the aircraft and missile industries is not a difficult task. Unfortunately, in other industries,

(*Continued on page 240*)



With the linear or toroidal pinch effect—an extremely high-temperature gas discharge at near vacuum—Consolidated's Systems Division is demonstrating a technique for producing temperatures in millions of degrees. This is one of CEC's newest nuclear instrumentation projects, which include uranium mass spectrometers, ion and neutron sources, isotope production, radiation data monitoring, and miniature research reactors. Write for the complete story in Bulletin CEC 3015-X1.

systems division **Consolidated Electrodynamics**

300 N. Sierra Madre Villa, Pasadena, California / Offices in Principal Cities Throughout the World

FOR EMPLOYMENT OPPORTUNITIES in this progressive company, write Director of Personnel.



Consolidated's twelve-inch sector, and high-speed cycloidal (right), Mass Spectrometers are designed for studies of ion-molecule reactions and thermal emission of solids, appearance potential measurements, free radical research, and quantitative analysis of products of fast reactions.

CIRCLE 49 ON READER-SERVICE CARD



Don't take POT LUCK

. . . insist on CIRCUIT SERVO POTENTIOMETERS for military applications







When equipment specifications are *strict* . . . when service conditions are *tough* . . . when you want extra design *flexibility* . . . CIRCUIT INSTRUMENTS helps you take the gamble out of specifying servo potentiometers.

The complete Circuit servo line, shown in actual sizes, makes available the following features to specification:

- Low torque operation
- Linear or non-linear windings
- Standard or high temperature operation
- Multiple taps
- Six standard case sizes
- Precision machined phenolic case where economy is required
- Precision machined aluminum case where specifications require
- Ability to meet and surpass MIL specifications
- Ability to gang up to 8 sections
- Standard specifications per section include:

  Power rating: 1 to 6 watts
  Resistance: 100 to 600,000 ohms
  Linearity: 0.5% standard; 0.1 special
  Rotation: Electrical . . . 350°; Mechanical . . . Continuous
  Weight: 0.5 to 6.25 ounces per section

Write for Data Sheets and information on CIRCUIT INSTRUMENTS' production flexibility for any size order.

IRC

INTERNATIONAL RESISTANCE COMPANY

CIRCUIT INSTRUMENTS INC.

Dept. 241, 2801 Anvil Street, North
St. Petersburg, Fla.

FOR ALL PRECISION POTENTIOMETER REQUIREMENTS: MINIATURE • SUB-MINIATURE • MOISTURE-SEALED • HERMETICALLY-SEALED • BALL BEARING • HIGH PRECISION • HIGH TEMPERATURE

Compu-tran



IRC SERIES 70-3000

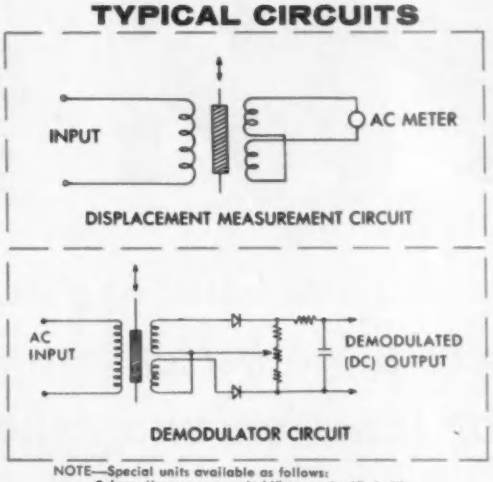
DISPLACEMENT TRANSDUCER

The IRC Displacement Transducer offers many new advantages, including lower cost. Its higher sensitivity and 0.1% linearity is specially suited to military instrumentation applications. The output is completely stepless and null voltage is 0.25% or less of total output. In addition, the output of standard IRC Displacement Transducers is high ...2 MV/Volt Input/Mil; all offer high output voltage in relation to size. Input voltages can be obtained up to 110 v. AC.

Compu-Tran Displacement Transducers show high resistance to moisture and shock . . . are available in 23 standard and sub-miniature sizes with a temperature range of −65 to +225°F. Also, IRC's Compu-Tran Displacement Transducers are the only units available completely encapsulated in a protective unit.

Designers of accelerometers and other measuring, indicating, gaging and process control devices will be especially interested in Compu-Tran Bulletin R-3. Write for your copy today.

TYPICAL CIRCUITS



NOTE—Special units available as follows:
- Long linear range unit (4" range in 6" shell)
- Power unit (110 volts, output 10 to 12 volts)
- Temperature compensative unit (insensitive to changes through range of −65°F to +225°F)

IRC

INTERNATIONAL RESISTANCE COMPANY

COMPUTER COMPONENTS DIVISION

Dept. 244 401 N. Broad St., Philadelphia 8, Pa.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

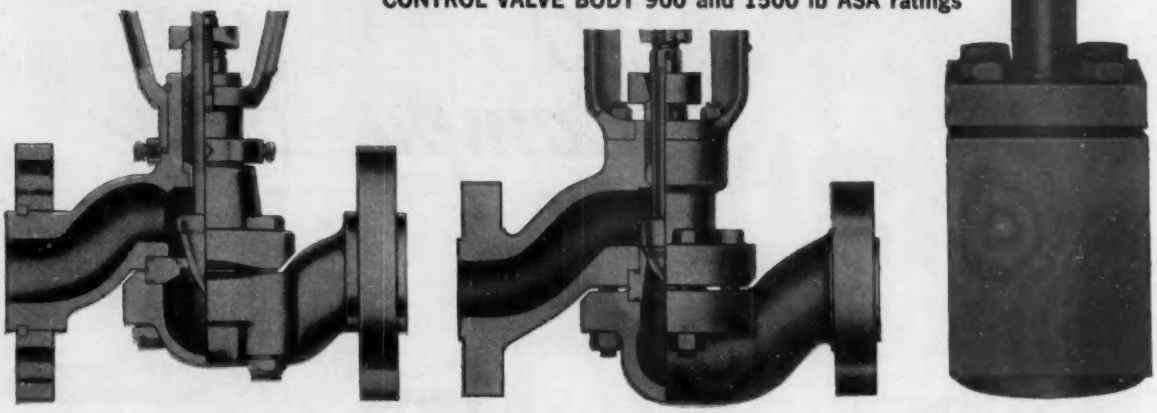
CIRCLE 51 ON READER-SERVICE CARD

CIRCLE 52 ON READER-SERVICE CARD →

MOLTEN METAL VALVE BODY

CONTROL VALVE BODY
600 lb ASA rating

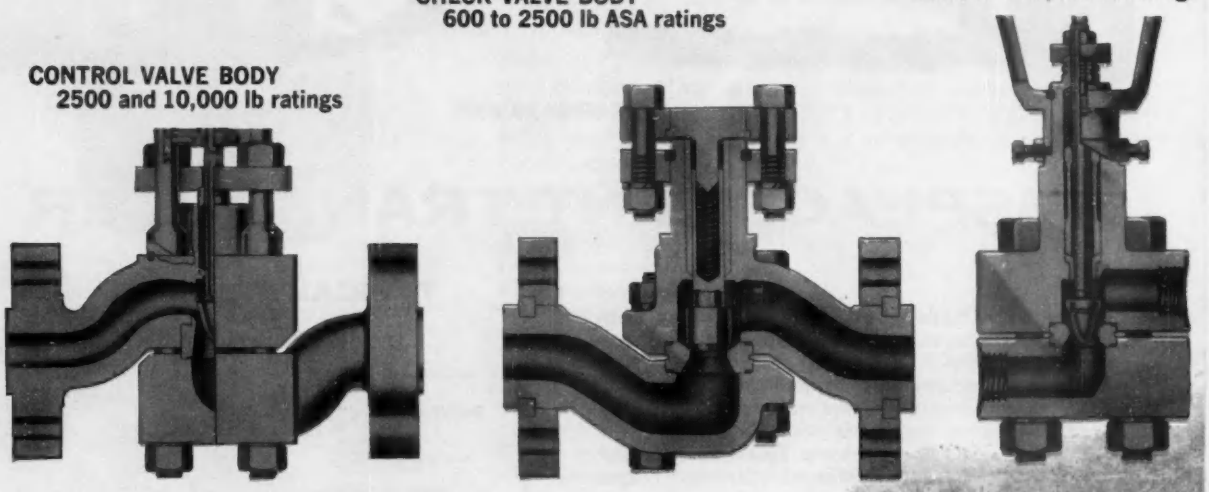
CONTROL VALVE BODY 900 and 1500 lb ASA ratings



CONTROL VALVE BODY
2500 and 10,000 lb ratings

CHECK VALVE BODY
600 to 2500 lb ASA ratings

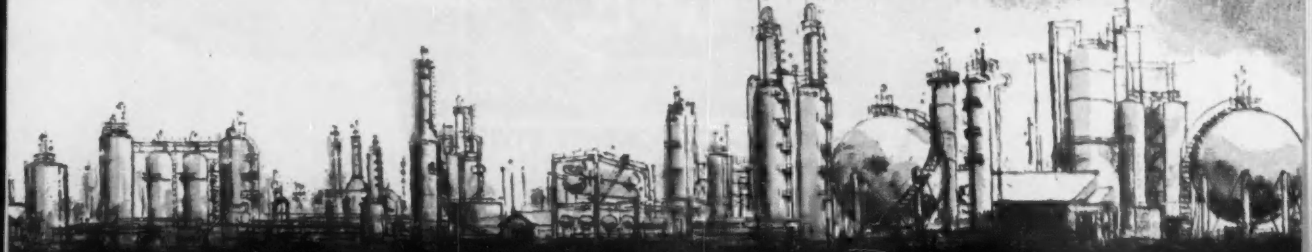
CONTROL VALVE BODY
2500 and 10,000 lb ratings



In all the world of process control
there is no better valve design
for function and reliability

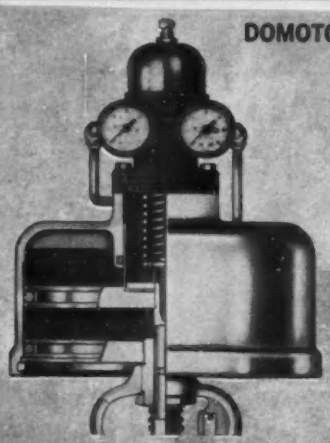
THE *Annin*

1040 SOUTH VAIL AVENUE, MONTEBELLO, CALIFORNIA



SEE ANNIN VALVES ON DISPLAY AT THE 13TH ANNUAL ISA INSTRUMENT

DOMOTOR OPERATOR



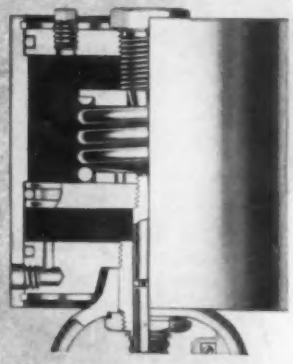
GOAL.....

CONTROL?

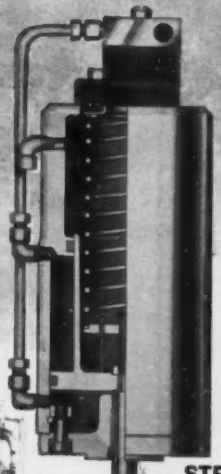


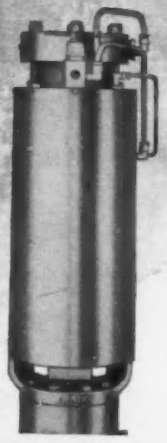
ELECTRO-PNEUMATIC DOMOTOR OPERATOR

ANNIN VALVE BODIES AND OPERATORS

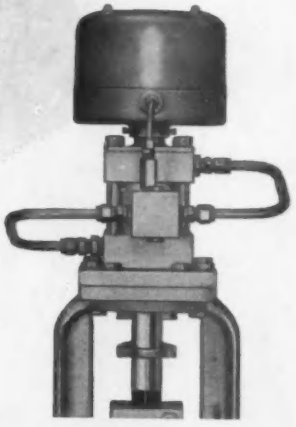


CYLINDER OPERATOR





PNEUMATIC-HYDRAULIC OPERATOR



ELECTRO-HYDRAULIC OPERATOR

STROKE POSITIONING OPERATOR

COMPANY

DIVISION OF THE ANNIN CORPORATION

AUTOMATION CONFERENCE AND EXHIBIT, SEPTEMBER 15-19, PHILADELPHIA, PA

Announcing

A new, highly accurate, yet inexpensive, method of speed measurement . . . monitoring . . . control. Applicable to machines, engines and transportation equipment.

this



TACH PAK

accepts a signal from a magnetic proximity pickup and conditions this signal for application to a meter calibrated directly in RPM — a control system — or a chart recorder. Installation is simple and there is NO maintenance problem.

AIRPAX
Control Specialists Since 1948

AIRPAX

SEMINOLE DIVISION

AIRPAX PRODUCTS CO.
FORT LAUDERDALE, FLORIDA

 CIRCLE 53 ON READER-SERVICE CARD

an Epsco transistorized

TRANSICON DATRAC®

can solve your data conversion problem . . . economically!



designed FOR YOUR SYSTEM by system specialists who have pioneered the field of high-speed, reversible analog-to-digital conversion . . .

- **PRODUCTION ENGINEERED** to be the lowest-cost transistorized converters available anywhere.
- **MODULARIZED**—plug-in building-blocks permit assembly of over 50 standard models.
- **EASY TO USE**—no adjustments
- **HIGH SPEED**—up to 25,000 conversions/sec analog-to-digital; up to 100,000 conversions/sec digital-to-analog
- **HIGH POWER DIGITAL OUTPUTS**
- **DIGITIZES BOTH CURRENTS AND VOLTAGES**
- **PARALLEL AND SERIAL CODED OUTPUTS**
- **BUILT-IN EXPANDABILITY**—8-bit converters to 10, 12 or 14 bits; changing codes from binary to binary-coded decimal; making an analog-to-digital converter from a digital-to-analog unit

. . . and an Epsco Exclusive: PROVEN RELIABILITY One million hours of operation in hundreds of installations around the world have proven DATRAC reliability. Now an all solid state TRANSICON DATRAC assures even greater performance.

New 6-page, 2-color brochure available with complete description of TRANSICON DATRACS. Write, wire or phone your local Epsco representative or contact, in the East: Epsco, Inc., Equipment Division, 588 Commonwealth Avenue, Boston 15, Massachusetts; in the West: Epsco-West, 125 E. Orangethorpe Ave., Anaheim, California.

TRANSICON ANALOG-TO-DIGITAL CONVERTERS FOR . . .

Data Logging Systems
Telemetry Data Reduction
Digital Transmission over Telephone Lines
Analog Digital Computer Linkages
Wind Tunnel Instrumentation

TRANSICON DIGITAL-TO-ANALOG CONVERTERS FOR . . .

Driving Analog Plotters from Digital Sources
Analog Displays on Meters and Oscillographs from Digital Codes
Analog Computer Inputs
Radar Display Drivers
Fire Control Simulators

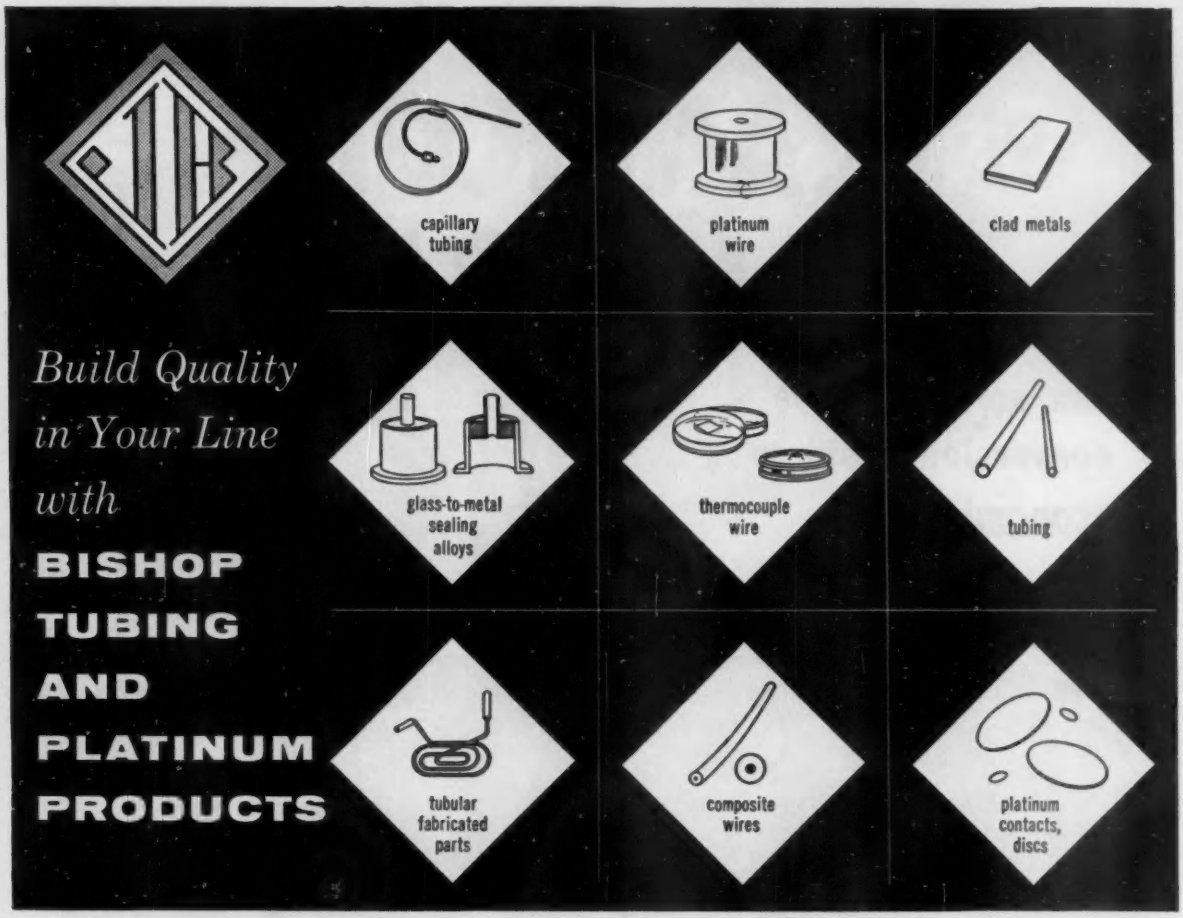
TRANSICON ALARM LIMIT MONITORS FOR . . .

Automatic Checkout Systems
High-speed Fault Analyzers
Power Plant Monitors
Industrial Process Controllers

Epsco

First in data control

CIRCLE 54 ON READER-SERVICE CARD



Build Quality in Your Line with

BISHOP TUBING AND PLATINUM PRODUCTS

"Metals for Precision and Performance"

Quality begets quality — it's an established axiom that premium products must begin with quality components. BISHOP has been producing platinum and precious metal products since 1842 . . . *precision* stainless steel tubing since 1931. The BISHOP family of metal products includes a broad variety of components for the designer, engineer . . . just to mention a few:

Capillary Tubing—stainless grades, standard sizes up to .130" OD
Platinum & Platinum Alloy Wire—#50 to #3 B & S Gauge
Clad Metals—base and precious metals in various combinations
Glass-To-Metal Sealing Alloys—low expansion alloys
Thermocouple Wire—noble metal and noble metal alloys
Tubing—nickel, stainless, platinum, special alloys up to 1" OD
Tubular Fabricated Parts—all varieties—conventional forming operations
Composite Wires—base and precious metals in various combinations
Platinum Contacts, Discs, Laboratory Apparatus

CATALOGS, DATA SHEETS SENT PROMPTLY ON REQUEST

Begin your next design with *unexcelled* quality BISHOP component materials. Write, wire or phone Malvern 3100.

Visit with us at our Booth #832, ISA Show

J. BISHOP & CO.

platinum works

MALVERN, PENNSYLVANIA

 CIRCLE 55 ON READER-SERVICE CARD CIRCLE 56 ON READER-SERVICE CARD →

ALLIED'S NEW ADDITIONS TO THE
KH SUBMINIATURE LINE

Types KHJ and KHY
GENERAL FEATURES:

Contact Data:

Contact Arrangement—DPDT
Contact Rating—
Low-level up to 2 amps at 29 volts d-c, 1 amp at 115 volts a-c 400 cps non-inductive or 0.5 amp inductive.
Life—100,000 minimum at 125°C

Also available 3 amps at 29 volts d-c, 2 amps at 115 volts a-c 400 cps non-inductive or 1 amp inductive.
Life—100,000 at 3 amps or 500,000 minimum at 2 amps at 125°C.
Initial Contact Resistance—0.05 ohms maximum
Contact Drop—1 millivolt maximum at low level rating, initial and during low level miss test

Operate Data:

D-C Coil Resistance—up to 10,000 ohms
Nominal Power—1.2 watts
Pull-in Power—240 milliwatts (standard)
100 milliwatts (special)
Operate Time—5 milliseconds max.
Release Time—3 milliseconds max.

Dielectric Strength:

1000 volts rms at sea level
500 volts rms at 70,000 feet
350 volts rms at 80,000 feet

Insulation Resistance:

10,000 megohms minimum at 125°C

ENVIRONMENTAL FEATURES

Vibration:

5 to 10 cps at 0.5 inch double amplitude
10 to 55 cps at 0.25 inch double amplitude
55 to 2000 cps at 20 g
Shock: 100 g's operational • 200 g's mechanical
Ambient Temperature: −65°C to +125°C

MECHANICAL FEATURES

Weight: 0.5 ounces

Terminals:

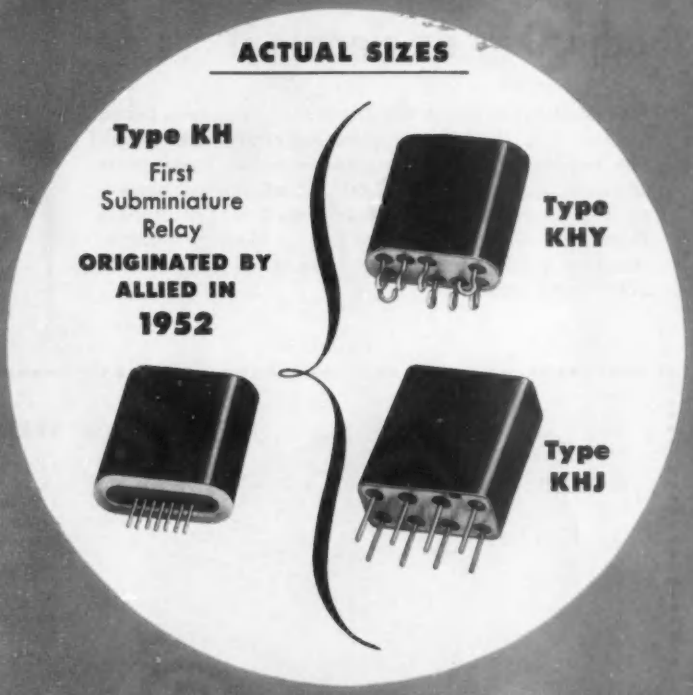
Hooked Solder • Plug-in • Printed Circuit

Mountings:

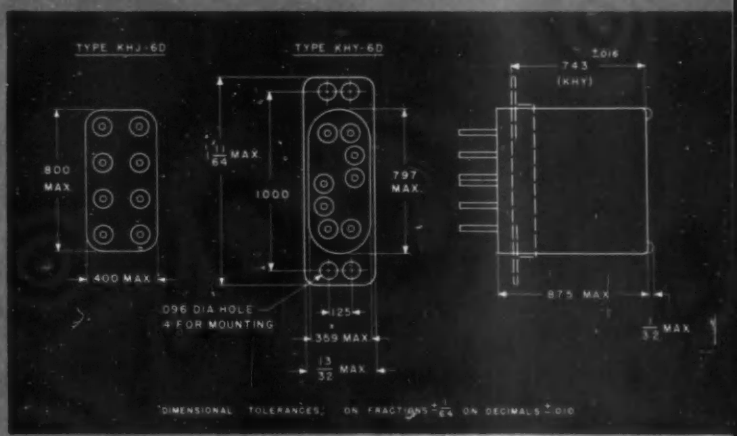
2 or 4 hole brackets at base or center of gravity
1 or 2 stud on top or side of housing

MILITARY SPECIFICATIONS

MIL-R-25018 • MIL-R-5757C



Allied's type KHJ and KHY subminiature relays were developed to meet the present "Automation" need for relays with incremental grid spaced terminals and with improved performance. These relays have a higher contact rating and are designed to meet the increased vibration and shock requirements of the latest MIL specs. They are available with mounting brackets that are interchangeable with Allied's present type KH subminiature relay.



ALLIED CONTROL

ALLIED CONTROL COMPANY, INC., 2 EAST END AVENUE, NEW YORK 21, N.Y.

VICTOR DIGIT-MATIC PRINTERS

Proved by over 16,000,000 printings without repairing, adjusting or cleaning!

The adding machine in the Digit-Matic has been tested with over 16,000,000 continuous printings, with no failure, no service other than periodic oiling. Forty years of experience in producing 1,500,000 adding machines—as well as precision instruments such as the Norden Bombsight—has given Victor Adding Machine Co. outstanding qualifications for producing rugged and reliable digital printers.

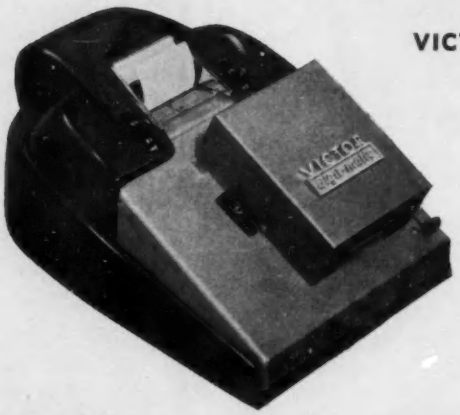
CHECK THESE 4 VICTOR ADVANTAGES

Reliability: Examine the rugged construction of a Victor machine. Each part is conservatively designed to provide extended life and reliability. Wearing surfaces heat treated, cyanide hardened to stand up under constant use. All steel parts cadmium plated to prevent rusting.

Immediate Service: Factory-trained servicemen (and parts) are on call in more than 725 cities coast to coast.

Flexibility: At least 500,000 different combinations available, with speeds up to 33 characters per second. With Victor Digit-Matics you have your choice of listers, accumulators, or calculators *plus* an almost infinite number of other variations ranging from electrical noise filters to upside-down printing.

Fast Delivery, Low Price: Because of Victor's continuous high volume of adding machine production, we can ship almost any quantity of Digit-Matics—built specifically to your order—within 30 days. Victor Digit-Matics, from only $425.00, are the value buy in the digital printer field.



VICTOR SERIAL ENTRY DIGIT-MATIC PRINTER

10 Digit solenoids. Digits are entered in sequence with most significant digit first. Accepts digits at a rate up to 20 per second. Print cycle: listers 0.27 seconds; accumulators 0.35 seconds. Available in up to 11 column entry capacity.

COIL DATA

Voltage	21-28VDC	42-54VDC	125-160VDC
Resistance, ohms			
Digit solenoid	25.5	75.0	490.
+ or − Print solenoid	25.5	75.0	450.
Minimum on time, seconds	.02	.02	.02
Maximum on time, seconds (continuous printing)	.05	.05	.05

Minimum off time between digits—all serial entry machines—.025 seconds.



COVER REMOVED

VICTOR PARALLEL ENTRY DIGIT-MATIC PRINTER

All digits 1 through 9 of each column equipped with solenoids. Digit and print command solenoids may be simultaneously energized. Print cycle:—listers 0.30 seconds; accumulators 0.35 seconds. Available in up to 10 columns entry capacity.

COIL DATA

Voltage	20-28VDC	35-56VDC	125-160VDC	105-125VAC
Resistance, ohms				
Digit solenoid	17.6	53.0	700.	125.
+ Print solenoid	17.6	89.0	375.	125.
− Print solenoid	17.6	53.0	375.	125.
Minimum on time, seconds	.020	.020	.015	.025
Maximum on time, seconds (continuous printing)	.050	.050	.035	.050

A few popular model variations:—columnar spacing; right side of machine accumulating and left side listing data identification; Non-Add printing; Non-printing adding; MIL-I-17623 Electrical Motor Noise elimination; Induction Motors; Manual Keys over the solenoids; "digit key depressed" switch (serial entry Digit-Matics); tag and label printing; and all kinds of alphabetic and special types.

Write today! Victor's electronics-trained staff will gladly help you solve any digital printing or calculating problem.

Write for technical manual No. B9-71.

Electronics Division

VICTOR ADDING MACHINE CO.

3900 N. Rockwell Street, Chicago 18, Ill.

MAROTTA'S NEW AUTOMATICALLY OPERATED REMOTELY CONTROLLED PNEUMATIC PRESSURE REGULATOR



CONTROL BOX

SPECIFICATIONS:

Model:

Regulator—¼" dome loaded pneumatic pressure reducer

Remote control type 24 V.D.C. Solenoid operated

Pressure Characteristics:

Inlet, outlet, and gage ports per MS 33656-4

Inlet pressure range—30 p.s.i.g. to 6000 p.s.i.g.

Proof pressure—9000 p.s.i.g.

Burst pressure—15,000 p.s.i.g.

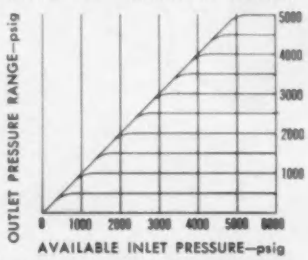
Outlet pressure range—30 p.s.i.g. to 5000 p.s.i.g.

Proof pressure—7500 p.s.i.g.

Burst pressure—12,000 p.s.i.g.

Rated Capacity 0.1 (SCFM/PSIA) min. (as defined in MIL-R 8572A)

REGULATED PRESSURE RANGE



OUTLET PRESSURE ONCE SET REMAINS CONSTANT AND NOT AFFECTED BY INLET PRESSURE VARIATION



RV-23E SERIES

SAFE! UNPRECEDENTED IN RESPONSE AND SENSITIVITY.

Not only does Marotta's new RV-23E Regulator Series load and vent pressure with push-button efficiency over a wider pressure range than any existing regulator or series of regulators, but is the only regulator meeting automation demands... the RV-23E can be programed to operate systems at a different pre-determined pressure level sequence.

Write or call for complete information. Experienced engineers available for consultation.



Marotta

VALVE CORPORATION

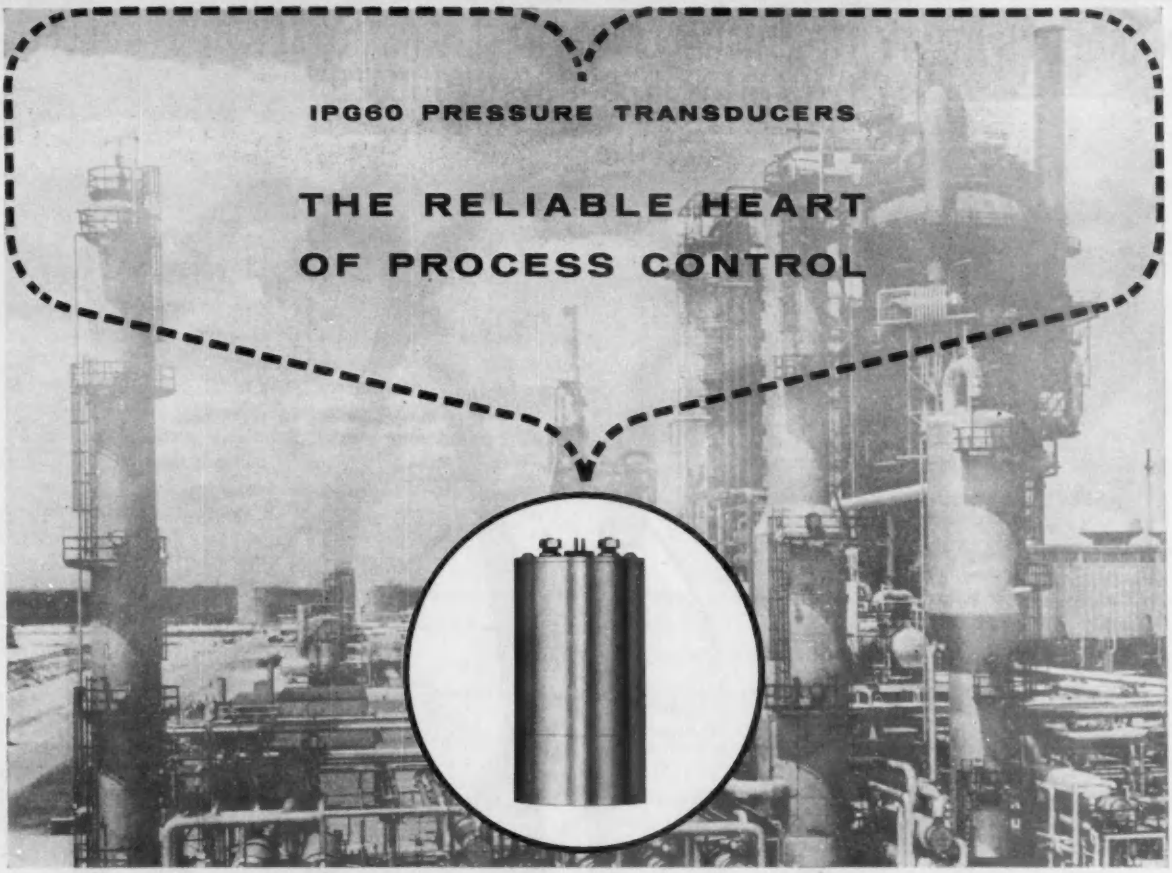
Pioneer Producers of High Pressure Valves

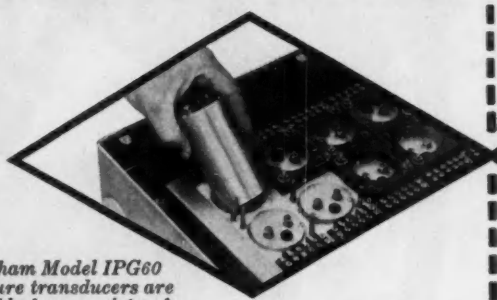
P.O. BOX 330-J BOONTON, N. J.

CIRCLE 58 ON READER-SERVICE CARD

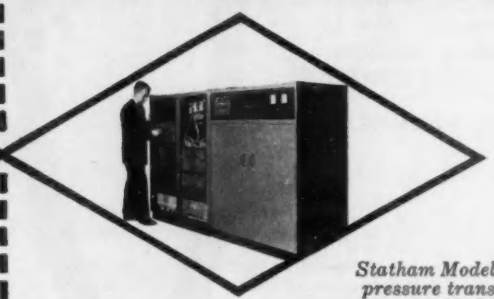
IPG60 PRESSURE TRANSDUCERS

THE RELIABLE HEART OF PROCESS CONTROL





Statham Model IPG60 pressure transducers are suitable for a variety of applications requiring accurate pressure measurements.



Statham Model IPG60 pressure transducers are specified for the Beckman 112 Data Processing Computer.

The evolution of industry toward automation has created a demand for precision data handling systems capable of monitoring and controlling process variables. Statham Model IPG60 pressure transducers are specified in the Beckman 112 Data Processing Computer — the first system of its type to meet successfully the stringent requirements of the process industry. The output of this highly accurate pressure transducer provides the Beckman system with vital information signals required for successful process control. Accuracy within ±¼% makes the Model IPG60 suitable for use in a wide variety of pressure measurement requirements. Complete data on the Model IPG60, or information on other Statham instruments, are available upon request.

OUTPUT: Approximately 35 millivolts full scale at 14 V. excitation
PRESSURE MEDIA: Non-corrosive fluids

Statham

RANGE: 0 to +15 psig.
NON-LINEARITY & HYSTERESIS: Not more than ±0.25% of full scale

STATHAM INSTRUMENTS, INC. of Puerto Rico, 254 Carpenter Road, Hato Rey, Puerto Rico · Cable Address: STATRICO

A SUBSIDIARY OF STATHAM INSTRUMENTS, INC. · 12401 W. OLYMPIC BLVD., LOS ANGELES, CALIF.

See you at Booth 944, I. S. A. Show, Sept. 15-19

 CIRCLE 59 ON READER-SERVICE CARD CIRCLE 60 ON READER-SERVICE CARD →

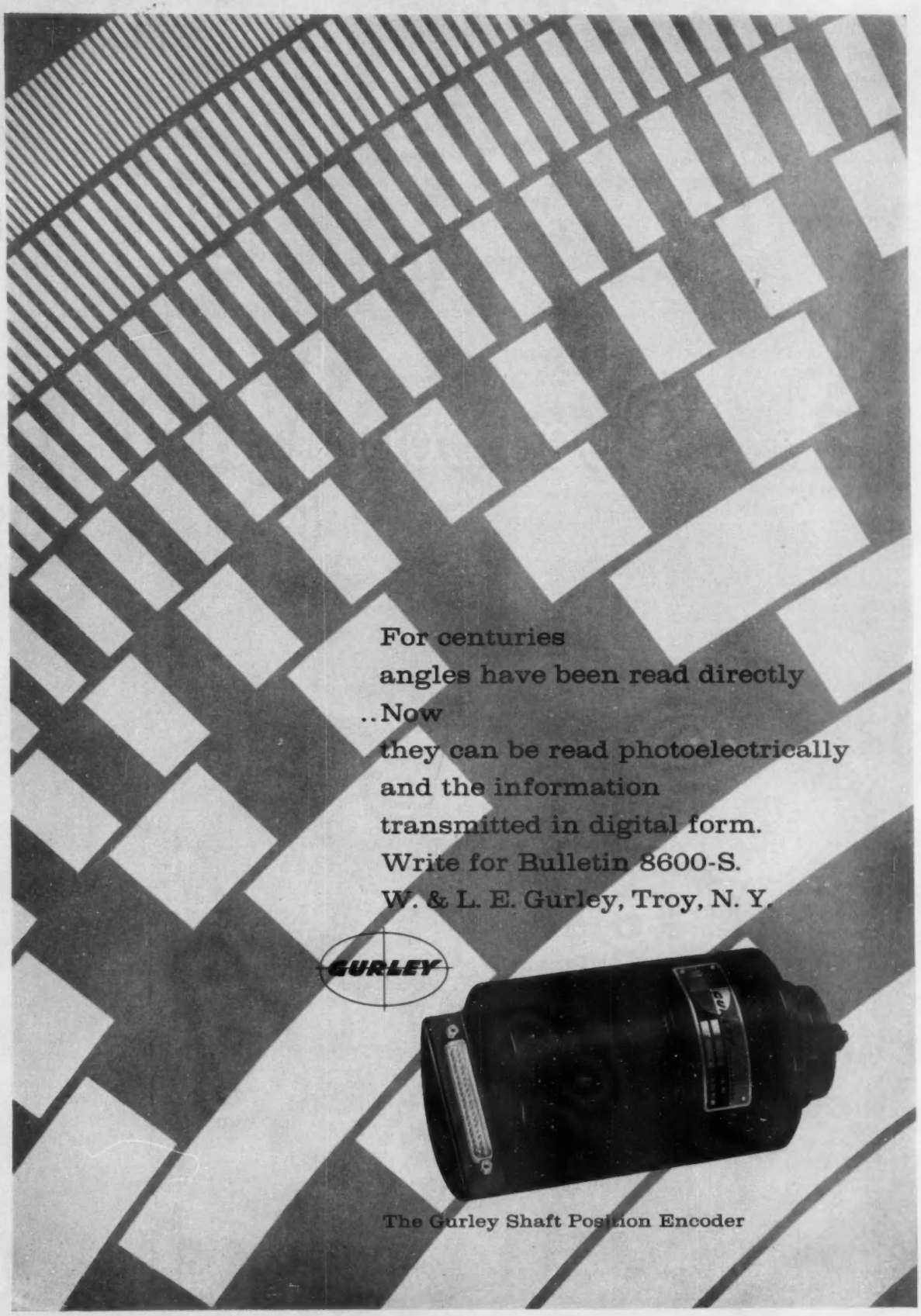
This is a direct descendant of the first continuously adjustable autotransformer, commercially developed and manufactured by General Radio Company in 1933.

Carefully designed, conservatively rated, and painstakingly manufactured, with Duratrak brush-contact surface . . .

this is the* 1,000,000th Variac®



* Additional thousands of special VARIACS have been designed for unusual applications

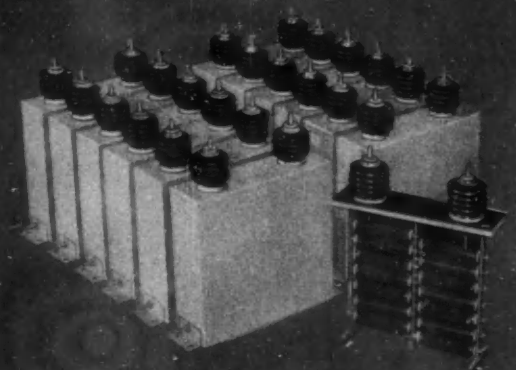

For centuries
angles have been read directly
..Now
they can be read photoelectrically
and the information
transmitted in digital form.
Write for Bulletin 8600-S.
W. & L. E. Gurley, Troy, N. Y.
GURLEY
The Gurley Shaft Position Encoder

Radio Receptor *hcd** petti-sel *selenium rectifiers*

**high current density*

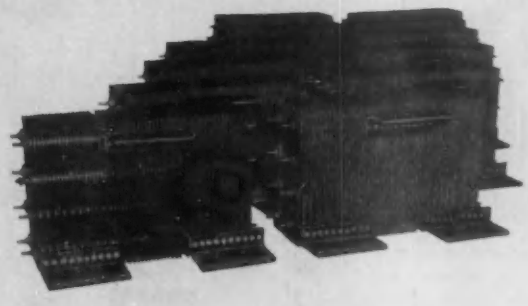
Life expectancy of 100,000 hours

800 ma D.C., 15,000 volts



High voltage, low current for smoke precipitation. 12 containers required.

50,000 amps, 9 volts D.C.



High current, low voltage, fan cooled. For electroplating power supply.

makes them first choice for these applications

The engineers who specified these Radio Receptor rectifiers know the outstanding record of similar stacks in Germany and throughout the world. They also know they can install RRco. Petti-Sel rectifiers once and forget them, confident they'll deliver up to 100,000 hours of trouble-free performance!

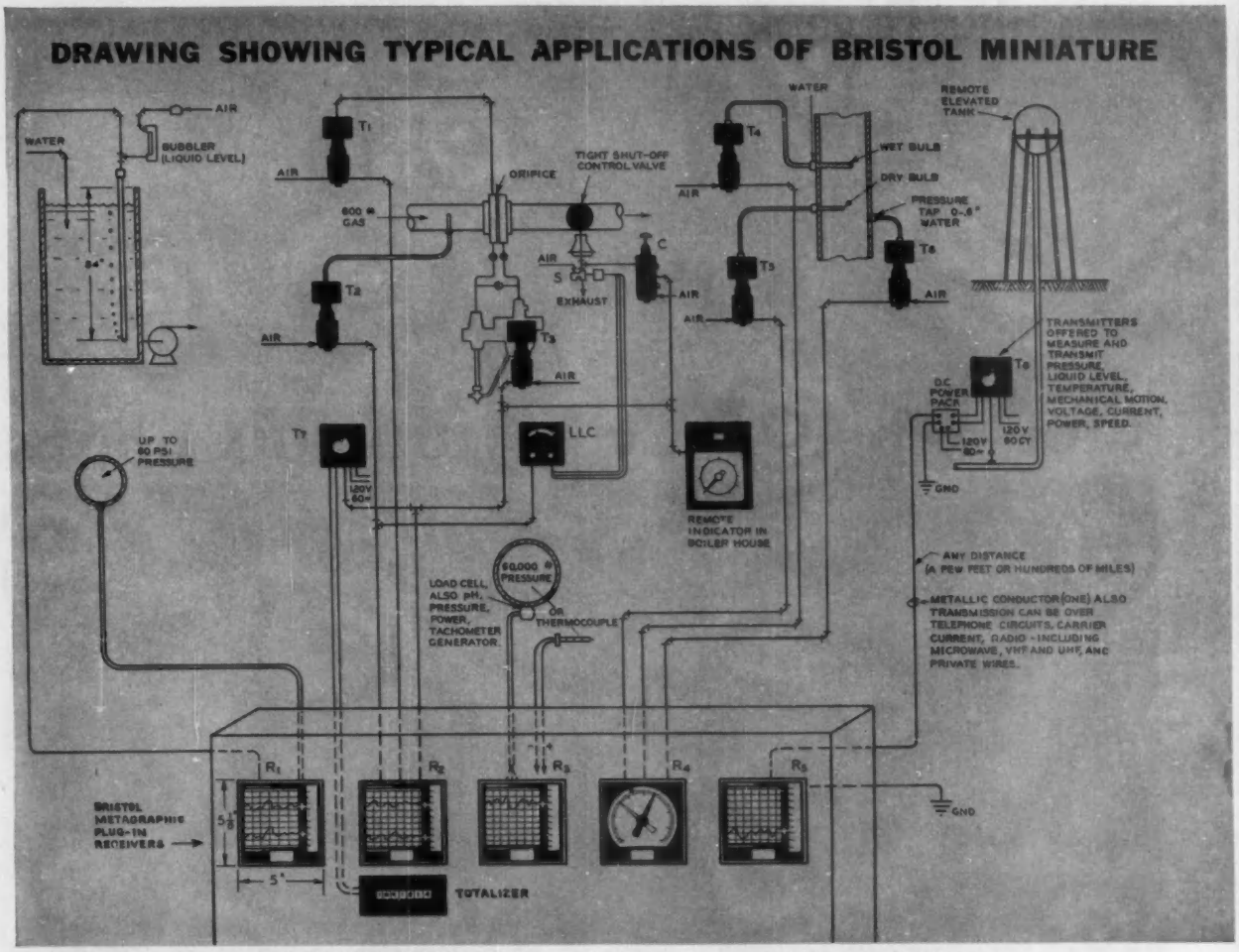
Produced by the improved new vacuum process developed by Siemens of West Germany, and now manufactured exclusively in the U. S. by Radio Receptor, Petti-Sel rectifiers are available in an even wider range of current and voltage ratings than indicated above. We'll gladly send you information regarding your rectification problems. For prompt attention, write today to Section CE-9.

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RADIO RECEPTOR COMPANY, INC.
Subsidiary of General Instrument Corporation
240 Wythe Avenue, Brooklyn 11, N. Y. EVergreen 8-6000

General Instrument Semiconductors

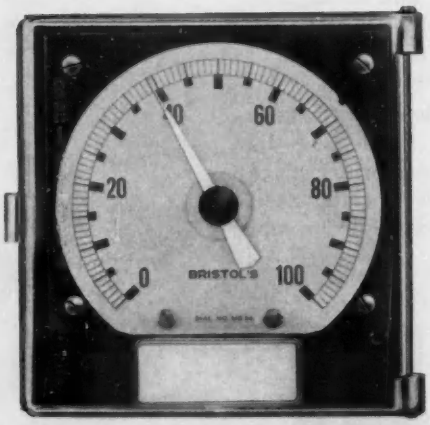
GENERAL INSTRUMENT CORPORATION ALSO INCLUDES
AUTOMATIC MANUFACTURING DIVISION • F. W. SICKLES DIVISION
MICAMOLD ELECTRONICS MANUFACTURING CORPORATION (SUBSIDIARY)

CIRCLE 62 ON READER-SERVICE CARD



ALL RECEIVERS LOOK ALIKE ON GRAPHIC PANEL, and all take the same panel cutout (4 9/16" sq.)

Bristol offers: **More types of miniatures**



BRISTOL METAGRAPHIC INDICATORS feature easy-to-read 9-inch effective length scale and interchangeability with recorders of same type.

Bristol Miniature Instrument Systems offer broadest measurement range and widest process control coverage:

- ***Pneumatic Transmission***
- ***Electronic Potentiometers and Bridges***
- ***Telemetering Instruments***
- ***Recording Gauges***

Automatically Controlling, Recording, and Indicating Models

"See our complete Line of instruments in Booths 1217 through 1225 at the ISA Show"

INSTRUMENT SYSTEMS

LEGEND

BRISTOL* METAGRAPHIC TRANSMITTERS

T_1 Pressure
T_2 Temperature
T_3 Differential Pressure or Flow
T_4 Temperature (Wet Bulb)
T_5 Temperature (Dry Bulb)
T_6 Pressure (as low as 0 to 5 mm mercury)
T_7 Integrator
T_8 Liquid Level Metameter Telemeter

*Metagraphic Transmitters are available for temperature, pressure, vacuum, differential pressure, flow, liquid level, mechanical motion, and through the use of the Bristol Dynamaster† Electronic Transmitter any input signal in the form of voltage, current, or change of resistance, capacitance, or inductance such as pH, speed, strain, density, etc.

BRISTOL RECEIVERS

R_1 Pressure or/and Liquid Level Recorder
R_2 Metagraphic Recorder (up to 2 records and 1 indicator)
R_3 Dynamaster Electronic Potentiometer or Bridge
R_4 Metagraphic Indicator—one, two, or three pointers for wide range of measurements or two pointers and one manual remote control.
R_5 Metameter† Telemeter

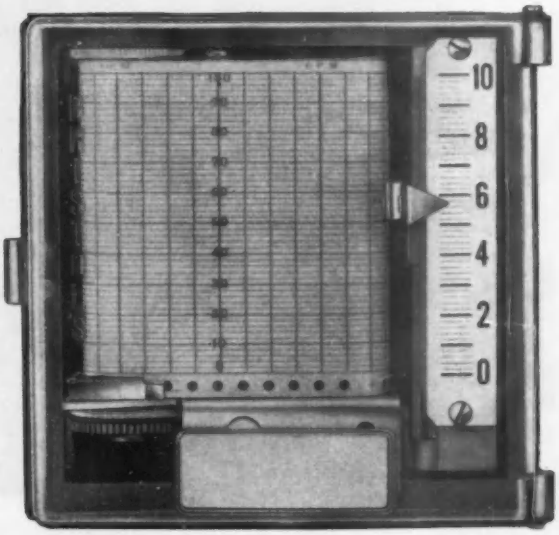
†T. M. Reg. U. S. Pat. Off.

BRISTOL METAGRAPHIC CONTROLLERS

(36 models to choose from—by far widest variety available)

Five Modes of Control

1. On-Off (Fixed High-Gain)
2. Proportional (Adjustable Gain)
3. Proportional-plus-Reset
4. Fixed-Proportional plus Fast-Reset
5. Proportional-plus-Reset-plus Derivative



BRISTOL METAGRAPHIC MINIATURE RECORDERS—whether electronic, pneumatic, telemetering, or gauge types—present a uniform, pleasing easy-to-read panel appearance, measure only 5″ x 5 1/8″, fit same 4 9/16″ square panel cutout.

than any other instrument company

. . . plus a complete line of full-sized instruments

Bristol makes them all. Whatever your choice in instruments, you need look no farther than the complete Bristol line—pneumatic, electronic, miniature telemeters and gauges—all in a *planned* line.

Planned to give graphic panel installations a neat, pleasing, matching appearance.

Planned to give you the widest possible measurement range, the broadest instrument coverage, of any line.

Planned to free you from costly pre-installation decisions as far as practically possible—true plug-in instruments; widest practical number of instrument substitutions; easiest, fastest range changes.

Planned to give you any type of instrumentation—electronic, pneumatic or mixed systems in plug-in miniature construction.

Planned to give you the results of modern human-engineering studies in chart, dial, and indicator visibility and readability.

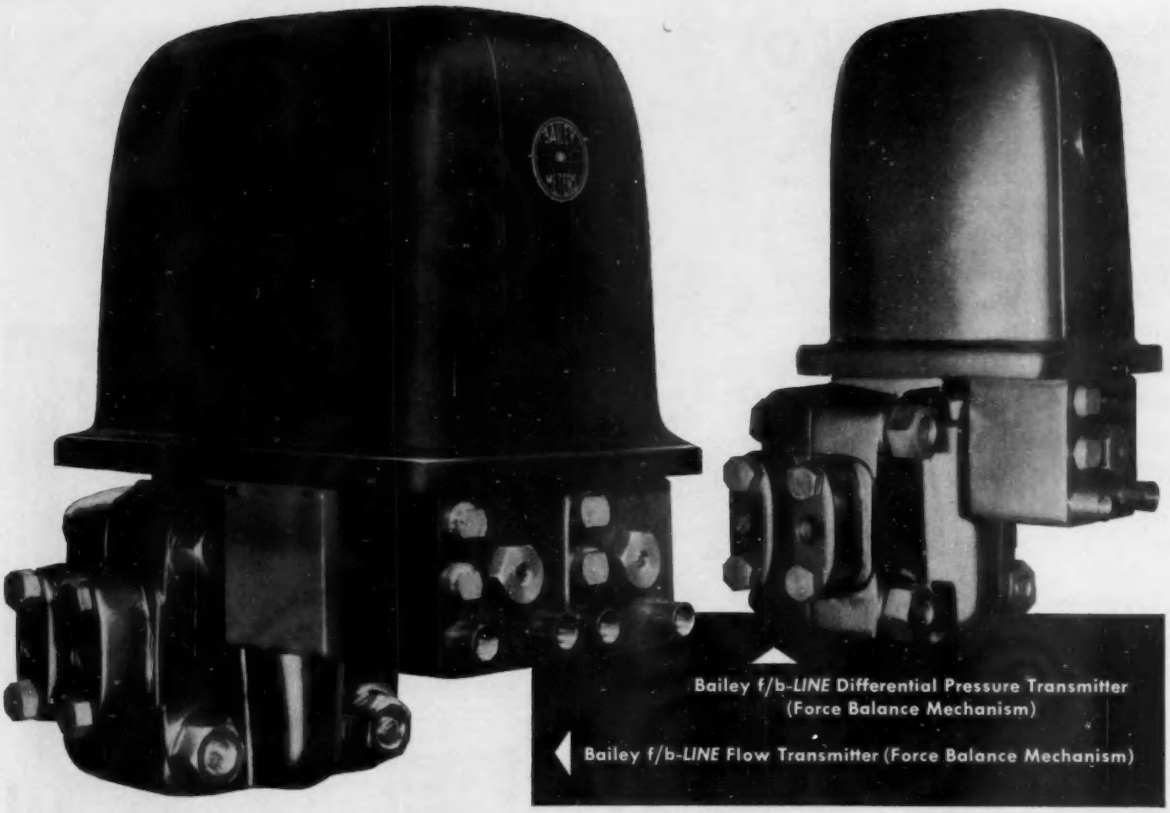
Bristol makes all types, all sizes of instruments, can give you all control modes. That's why Bristol application engineers don't need to shade the facts. When they make an instrument recommendation it's based on our unbiased consideration of *your* problem alone.

Write for complete technical data on Bristol miniature instruments today. The Bristol Company, 101 Bristol Road, Waterbury 20, Conn. B-6

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 63 ON READER-SERVICE CARD



Bailey f/b-*LINE* Differential Pressure Transmitter (Force Balance Mechanism)

Bailey f/b-*LINE* Flow Transmitter (Force Balance Mechanism)

Two new Bailey *f/b-LINE* Transmitters

permit new accuracy in measuring flow and differential pressure

Pneumatically transmits rate of flow—or differential pressure—measurements to indicating, recording, and/or controlling equipment at remote stations. Transmitters consist of a diaphragm measuring mechanism and a force balance pneumatic transmitting unit.

APPLICATION

For steam, water, air, gases and other fluids producing differentials across primary elements from 0-2 in. H_2O to 0-2000 in. H_2O at maximum service pressure of 50, 1500, and 5000 psig.

FEATURES

Transmits a Signal Directly Proportional to Rate of Flow. Uses receiver with uniformly-graduated chart or scale. Eliminates need for external square-root extractors or characterizers.

10 to 1 Turndown. Differential range of each diaphragm measuring element may be changed by factor of 10 to 1; e.g., 0-20 in. H_2O diaphragm may also measure 0-2 in. H_2O.

Screwdriver Adjustments. Range and zero adjustments readily accessible. Range may be changed with screwdriver adjustment.

Overpressure Protection. Protects against full service pressure applied to either side of diaphragm.

Fast Response. No viscous dampers needed, so speed of response is very fast.

Corrosion Resistant. For maximum differentials between 20 and 2000" H_2O, all parts in contact with process fluid may be stainless steel. No sealing fluids or sealing diaphragm required.

Good Stability. Reset type boosters give good stability with high gain.

Versatile Mounting. May be mounted on process piping, wall, or separate mounting pipe using same bracket.

For additional information, call your local Bailey District Office, or write direct. G46-1

See these new instruments at the ISA Show

Instruments and controls for power and process

BAILEY METER COMPANY

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In Canada—Bailey Meter Company Limited, Montreal

not for nearsighted design engineers

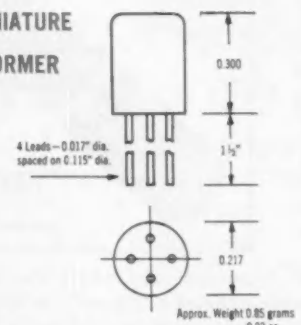


NEW *ESC* MICRO-MINIATURE PULSE TRANSFORMER

Fractional Micro-Second Pulse Width

Where space and weight limitations are precious, ESC's new Micro-Miniature Pulse Transformer fills a vital need in missiles, computers and other electronic equipment. ESC Micro-Miniature Pulse Transformers can be custom built to your specifications for both military and commercial applications. Write for complete technical data today!

ESC MICRO-MINIATURE PULSE TRANSFORMER



electronic components division

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exceptional employment opportunities for engineers experienced in pulse techniques

Pulse transformers • Medium and low-power transformers • Filters of all types • Pulse-forming networks • Miniature plug-in encapsulated circuit assemblies • Distributed constant delay lines • Lumped-constant delay lines • Variable delay networks • Continuously variable delay lines • Pushbutton decade delay lines

HETHERINGTON

SWITCHES • INDICATOR LIGHTS • SPECIAL ASSEMBLIES

ENGINEERING NEWS

Space-Saver Toggle Gives Big Switch Performance

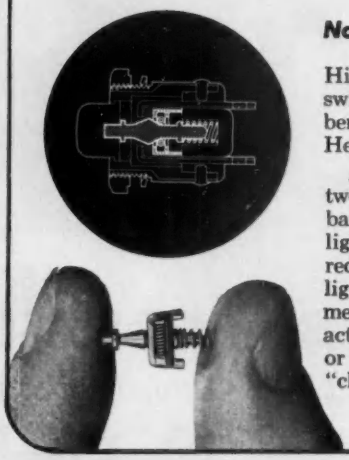


When it comes to making a *real* saving in space, this new SP-DT Hetherington Toggle Switch is the answer. It is only $1\frac{1}{32}$" in diameter by $1\frac{9}{32}$" long. It weighs less than ¼ oz. Yet it breaks 5 amp. resistive loads at 28 volts dc (2½ amps @ 115 v ac) for 50,000 operations.

Best of all, Hetherington's tease-proof cam-roller snap-action gives the T3103 the "feel" of a real heavy-duty switch. Details are in Data Sheet S-3a.

The Switch Design That Says "NO FOOLIN"

No Tease . . . No Deceptive Clicks



Higher ratings in smaller, lighter-weight switches are made possible by this little beryllium device . . . the heart of every Hetherington snap-action switch.

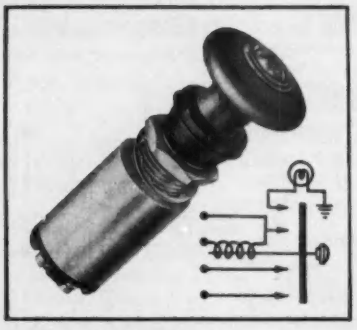
A polished tapered rod operates through two compression springs in the shorting bar and against the return spring. Its lightning-fast, double-break snap action reduces arcing and contact welding to negligible proportions—even with high momentary overloads. Contact pressure is actually greatest at the point of "make" or "break" thus preventing deceptive "clicks" or contact teasing.

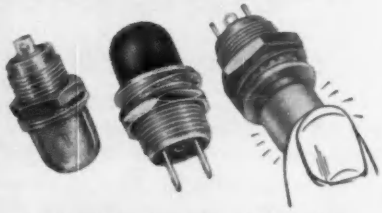
Relay, Switch, and Pilot Light Functions in One Unit Only $\frac{15}{16}$" x $3\frac{7}{8}$"

This "control engineer's delight" does the work of *two* conventional switches plus a holding relay and an indicator light. All of this is accomplished in only a fraction of the space, weight, and wiring needed for separate components.

Once the button is pressed, a built-in 28-volt solenoid holds the switch on contact until either the coil circuit is externally interrupted or the button is pulled out. A built-in indicator light shows when the coil circuit is energized.

Modifications of this basic Hetherington Holding Coil Switch design include a variety of circuit arrangements. Pull-on and push-on pushbutton types as well as a toggle type are available. Their many aviation and industrial uses center around jobs where the switch is manually "closed" to start an operation; then electrically "opened" at the end of the sequence. In an emergency, the switch may be manually opened in the middle of the sequence if desired.





W-I-D-E Angle Visibility from Indicator Lights only $1\frac{1}{64}$" Long

Almost 50 percent of the surface of these tiny units is useful illuminated area. Thanks to a specially-beveled lens cap, light is "piped" evenly throughout the entire lens. Full 180-degree visibility is assured on either standard or edge-lit panels.

These miniature Hetherington Series L6000 lights come in both 2-terminal ungrounded, or 1-terminal case-ground styles. Single piece terminals and contacts cannot be torn loose by heavy wires. Request Bulletin L-2b.

HETHERINGTON INC. DELMAR DRIVE, FOLCROFT, PA. • 139 Illinois St., El Segundo, Calif.

Over 455 PRECISION push-button Switch Types

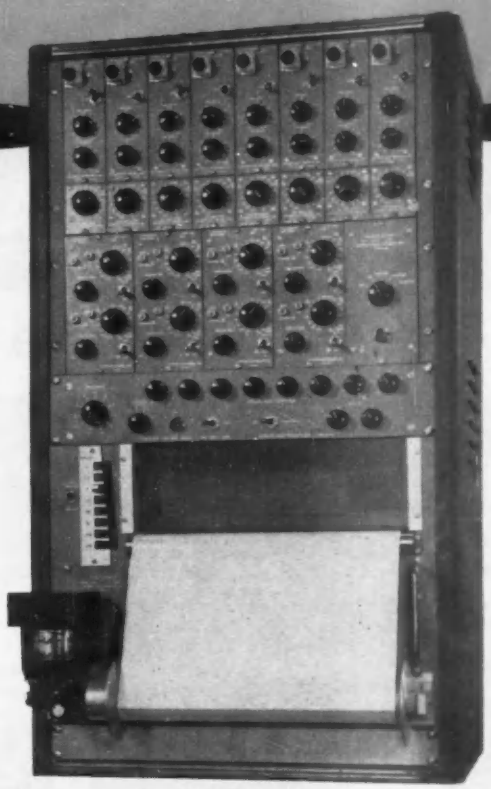
A Controls Company of America Subsidiary

OFFNER ALL TRANSISTOR TYPE R DYNOGRAPH

the most versatile...most sensitive direct writing unit available

Combining all these features...

- ☆ stable d-c sensitivity of one microvolt per mm
- ☆ true differential input
- ☆ high input impedance
- ☆ response to beyond 150 cps.
- ☆ reluctance, differential transformer, strain gage with a-c or d-c excitation, thermocouples, etc., used with all amplifiers
- ☆ deflection time less than 2 milliseconds
- ☆ fixed precision calibration
- ☆ instant warm-up
- ☆ precision source for d-c and 400 cycle excitation, self-contained
- ☆ zero suppression, twenty times full scale, both directions



all these features...plus 8 channels in only 33¼" of rack space

Whatever your application for direct writing recorders . . . you should investigate the ability of the Offner Type R Dynograph to do the job *better* and more *simply*. Using transistor circuits* developed and tested for over two years in hundreds of channels of Offner medical equipment, the Type R Dynograph is, we believe, superior in practically every respect to *any other* direct writing oscillograph. Write on your company letterhead for literature giving details and specifications.

*Patents granted and pending

FULL SCALE, UNRETOUCHED CHARTS PRODUCED ON THE TYPE R DYNOGRAPH



EXTREME SENSITIVITY—

10 Microvolt RMS Sine Wave — **Ten Microvolt D-C Square Wave**

Four recording media. Heat or electric rectilinear — ink or electric curvilinear. Readily convertible.

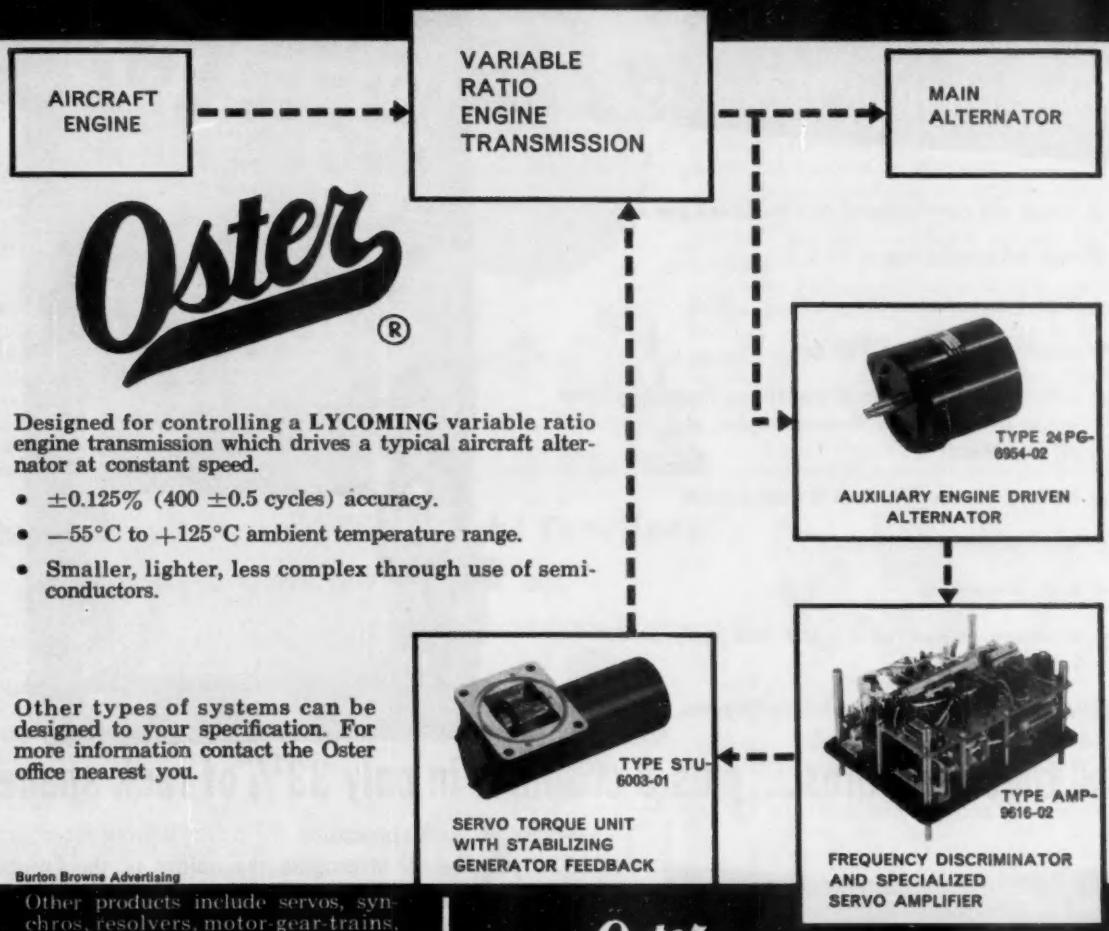
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FREQUENCY DISCRIMINATOR AND SERVO DRIVEN CORRECTION LOOP

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Other types of systems can be designed to your specification. For more information contact the Oster office nearest you.

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Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms.
Contact Mr. Robert Burns, Personnel Manager, in confidence.

CIRCLE 68 ON READER-SERVICE CARD CIRCLE 69 ON READER-SERVICE CARD →

SILICON RECTIFIERS

designed and manufactured to meet



THE NEW JAN SPECIFICATIONS

For AXIAL LEAD TYPES

JAN 1N538 (MIL-E-1/1084A)	JAN 1N540 (MIL-E-1/1085A)	JAN 1N547 (MIL-E-1/1083A)

now from AUTOMATIC

Maximum Values for AUTOMATIC Military Type Silicon Rectifiers designed to meet the new JAN MIL-E-1 Specification

Type No.	Peak Reverse Voltage (VDC)	DC Output Current @ 25° C. Ambient (MA)	DC Output Current @ 150° C. Ambient (MA)	Maximum Reverse Current* (MA)	Mounting	MIL-E-1 Technical Spec. Sheet No.
JAN 1N538	200	750	250	0.350	Axial lead	1084A
JAN 1N540	400	750	250	0.350	Axial lead	1085A
JAN 1N547	600	750	250	0.350	Axial lead	1083A

*Averaged over 1 cycle for inductive or resistive load with rectifier operating at full rated current at 150° C. ambients.

PRODUCTION QUANTITIES OF ALL TYPES AVAILABLE FOR FAST DELIVERY

Naturally, you can get these new axial lead JAN types direct from AUTOMATIC, and from authorized distributors throughout the country – and at prices that reflect General Instrument's years of volume production experience.

Together with the earlier JAN type stud mount group, AUTOMATIC now covers the entire medium power silicon rectifier field for the requirements of every military application.

More information? A complete set of data sheets is yours for the asking. Please write us today.

GENERAL INSTRUMENT SEMICONDUCTORS

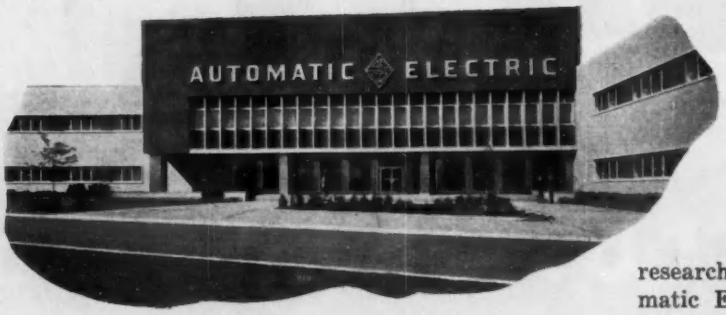
General Instrument Corporation also includes F. W. Sickles Division, Radio Receptor Co., Inc., and Micamold Electronics Manufacturing Corporation (Subsidiaries)

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MASS PRODUCERS OF ELECTRONIC COMPONENTS

AUTOMATIC MANUFACTURING DIVISION OF GENERAL INSTRUMENT CORPORATION
65 GOUVERNEUR STREET, NEWARK 4, N. J.

INSIDE reasons why AE



VISIT OUR NEW PLANT at Northlake, Illinois, and you'll see reasons for the widespread acceptance of Automatic Electric Relays and Switches–the vital components of electrical control devices used throughout industry.

The inside story here is *quality*–quality that starts with basic design and material specifications–quality that comes from continuous research and constant improvements by Automatic Electric engineers–quality assured by precision manufacturing methods and checked by the most rigid tests.

To users in every field, it means long-life dependability in relays, stepping switches and other products. On top of that, this new 35-acre plant *doubles* our previous output capacity. Most modern and completely equipped in the industry, it enables us to meet your demand for quick delivery of precision relays and switches in volume. Let's discuss *your* requirements.

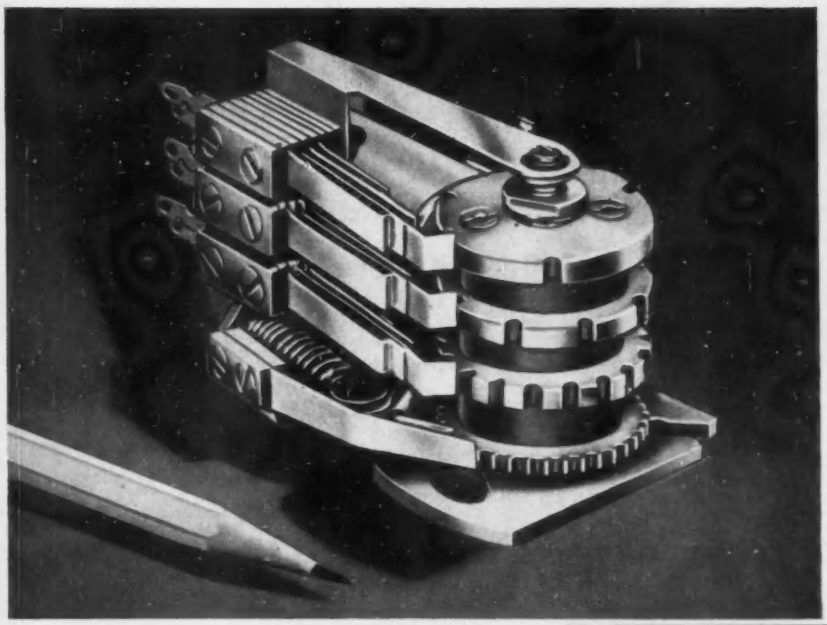


Contact points that stay on for keeps are assured by a unique process whereby we weld the end of a continuous length of wire to the spring bank *with very accurate control of time and voltage* to provide a perfect weld with exactly the right amount of material. Microscopic inspection after welding checks for accurate shape, size and position (per inset photo).



Solderless splice eliminates open coil windings, a common source of relay trouble. We make the splice by removing the insulation from a considerable length of wire and twisting several strands of bare tinned copper wire tightly about the ends of the wires of the coil winding. This produces a flexible connection not subject to attack of electrolysis, and highly resistant to strain.

Relays outperform them all



New "Series OCS" Cam-Type Relay combines relay and stepping switch functions. This versatile, shock-resistant relay (up to 25 G.) can be used to replace the delicate latch-in type, plus whole banks of relays or combinations of relays and stepping switches. For complete data write: Automatic Electric Sales Corporation, Northlake, Illinois. In Canada: Automatic Electric Sales (Canada) Ltd., Toronto. Offices in principal cities.



Metal parts enter one of Automatic's two electrically heated roller hearth annealing furnaces. Annealing serves to: (1) produce the best metallic structure for magnetic field, and (2) relieve machining strains. Periodic check of annealing atmosphere by chromatograph assures proper mixture of gases. Thanks to painstaking care like this at every step of manufacture, Automatic Electric Relays are the most reliable you can buy.

AUTOMATIC ELECTRIC

Northlake, Illinois

Subsidiary of **GENERAL TELEPHONE**

CIRCLE 70 ON READER-SERVICE CARD

Announcing

Honeywell
AccuData® I d-c Amplifiers

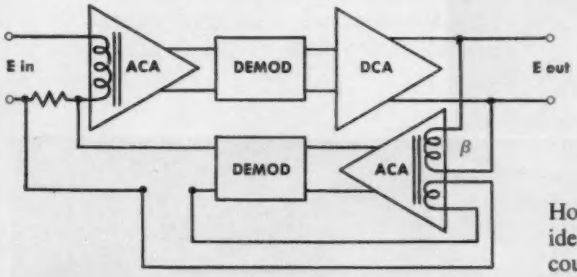


Model 2HDH-61
shown approx. ½ size

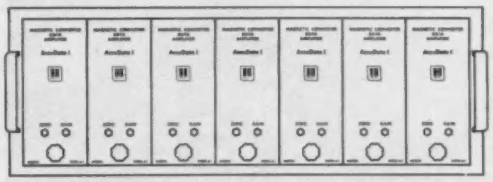
isolated differential input for strain gage, thermocouple and resistance bridge measurements

frequency response to 100 cps

100,000 ohm input resistance



The principal feature of this new development is a completely closed loop wideband feedback circuit which provides a highly accurate isolated signal connected in series opposition to the input emf.



The AccuData I d-c Amplifier is 5¼" high and is designed to mount seven to a 19" relay width. A frame assembly is available for this purpose. Separate power supplies (not shown) are used, having 2, 7, 14, or 49 channel capabilities.

Honeywell's new AccuData I d-c Amplifiers combine two Honeywell Second Harmonic Magnetic Converters to provide ideal d-c transducer preamplifier characteristics. Thermocouples, grounded or ungrounded; resistive strain gages operated from common power supplies; and other low-source impedance d-c devices are perfectly suited as inputs to this highly accurate d-c amplifier. The input circuit, with input impedance of greater than 100,000 ohms, is completely isolated from the output circuit and from ground.

The output is single-ended to match emf-input analog-to-digital converters. Overall non-linearity is 0.01%; gain instability, drift, and noise are less than 0.1%.

Other specifications: Response down 3 db at 100 cps; Rise time to 99.9% = 30 milliseconds; Input: 0 to 5 mv; Output: 0 to 1.0 volt; Output impedance: 0.01 ohms; Common Mode Rejection: at d-c virtually infinite; at 60 cps: 130 db (3,000,000 to 1).

Write for technical bulletin on the AccuData I, Model 2HDH-61, to Minneapolis-Honeywell, Boston Division, Department 34, 40 Life Street, Boston 35, Massachusetts.

Honeywell

First in Control

COMPUTER PROGRESS

Digital and Analog Computers at Work

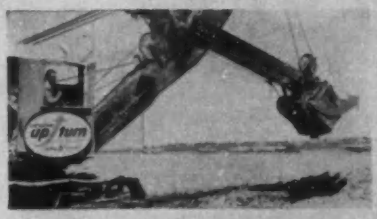
ARTICLE 4 VOLUME 1

COMPUTER DEPARTMENT LAUNCHES OPERATION UPTURN WITH NEW MILLION-DOLLAR PLANT IN PHOENIX, ARIZONA

General Manager H. R. Oldfield, Jr., is pictured at the controls of the Operation Upturn steam shovel which recently broke ground for the new 104,000 square foot permanent plant which is expected to be completed by December of 1958.

"Our business is good and getting better," Oldfield said. "We're going to continue to expand during the year, adding perhaps a hundred or more people." The department now has over 800 employees.

The 160 acre site is located in Deer Valley Park, northwest of Phoenix along the west side of the Black Canyon Highway and south of the intersection with Thunderbird Road.



COMPUTING SERVICES GROUP HANDLES COMPLEX ORIGIN-DESTINATION STUDY FOR WESTERN CITY

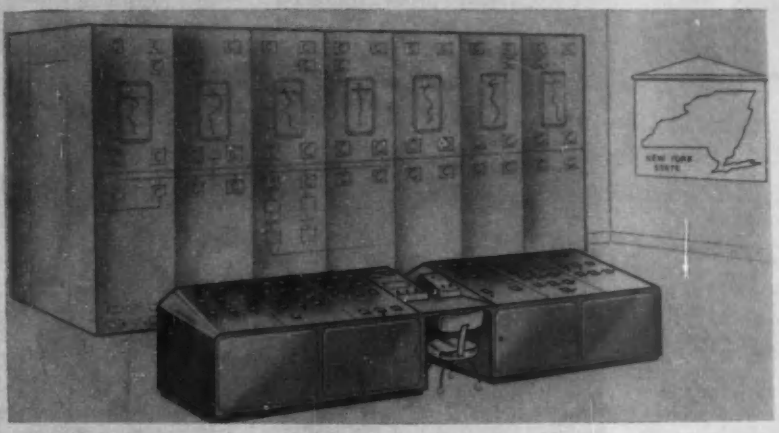
The Computing Services Center of the G-E Computer Department recently completed an origin-destination tabulation for the Phoenix-Maricopa County Traffic Study Group in Phoenix, Arizona. The results of this tabulation, when analyzed, will enable the group to plan the street and highway development program of this desert metropolis for years to come.

The original survey information was obtained by the city-county personnel using the interviewing procedures set up by the U. S. Bureau of Public Roads. The data was put on punched cards and then turned over to G-E for processing and tabulation.

Using manual, or simple computing methods, such tabulations often take many months—sometimes years—to complete. However, using General Electric's giant computer on a rental basis, the job was completed in just a few weeks. The Computer Department also performed the difficult programming job.

(Programming, simply stated, is the translation of the solution method into the language a computer can understand, and the issuance of instructions to the computer so that it will process the information it is fed.)

NEW ECONOMIC DISPATCH COMPUTER SCHEDULES POWER INTERCHANGE BETWEEN FOUR AREAS FOR EASTERN UTILITIES



This new transistorized Economic Dispatch Computer, developed by G-E's Computer Department for the Niagara-Mohawk Power Corp. and the New York State Electric & Gas Corp., represents a significant advancement in the field of dispatch computers.

The computer simulates the equivalent of four power systems as separate operating areas, whereas all previous computers represented either a single system or a group of utilities as a single system. Since it includes Niagara-Mohawk's three operating areas and N.Y.S.E. & G., it represents a large part of the power system of upper New York State. It also incorporates equivalent representation of certain neighboring utility systems.

This special purpose analog computer will produce solutions in a matter of seconds for operating problems which in some cases would take hours or days of manual calculation. It considers individual generating unit efficiencies, fuel costs and transmission losses to assure minimum use of fuel. It automatically computes the optimum schedules of power flow between the four operating areas and the corresponding power flow in the individual interconnecting transmission lines between areas. The computed generating plant outputs and power flows are used by the system dispatcher to schedule system operation. This computer will also be used to determine cost and value of power transactions where large amounts of power are transmitted from one system to another and facilities of a third system may be involved.

Today's rapidly increasing demands for electrical energy have increased the need for this type of complex inter-area scheduling. The problems of operating multi-area systems where transmission line losses are involved have become so complex that a system operator must have a modern computer to accomplish his task adequately.

Although the understanding of how to achieve economic dispatch for such a system has been known for several years, the technique to make the theory practical has only recently been established. Basic theory for the system was developed by Dr. L. K. Kirchmayer and associates of General Electric's Analytical Engineering Section.

The Computing Services Center of G-E's Computer Department is staffed with 125 analysts, programmers, coders —all leaders in the computer field. Their services are available, along with time on the large and versatile type 704 computer, to handle the problems of industry, business, government and education.

For more information contact your nearest Apparatus Sales Office, or Computer Department – Room 224, General Electric Company, 1103 North Central Avenue, Phoenix, Arizona.

CPA–8

Progress Is Our Most Important Product

GENERAL ELECTRIC

DeJUR



..one source for all single turn precision potentiometers...

from ½" to 5"

- LINEAR AND NON-LINEAR
- HIGH PRECISION SINE-COSINE
- EXTERNAL PHASING, BALL BEARING

WIDE RANGE STANDARD LINE – You can solve most design problems with DeJUR'S standard line of precision potentiometers. Chances are we already make the potentiometer you need, or can design one for you. Here are some highlights on three types:

HIGH PRECISION, SINE-COSINE SERIES C-178–1⅞" diameter model is available in accuracies up to ± 0.3% peak-to-peak. Ball bearing construction, anodized aluminum housing. Multi-finger brush contacts. 2" and 3" diameters also available.

EXTERNAL PHASING SERIES C-200–2" diameter, sleeve or ball bearing. Stainless steel clamp ring ganging for unlimited phasing. Taps are field insertable without drilling. Available with any type mounting and shaft configuration.

HIGH RESOLUTION, HIGH ACCURACY – Available in 2", 3" and 5" diameters (Series HP-200, HP-300, HP-500). Linearity to ± 0.05%. Any electrical angle. Up to 30 taps. Ganging multiple, 0.368. Housings are of one-piece, glass reinforced Alkyd, and have anodized aluminum end plates.

DeJUR WINDINGS PROVIDE OPTIMUM RELIABILITY – All potentiometers are made by exclusive DeJUR bonding and cleaning methods that add to their high precision and long life. These production methods mean improved linearity, no loose turns, and no change in wire contour and winding resistance.

you're always sure with **DeJUR**



FREE TECHNICAL CATALOG

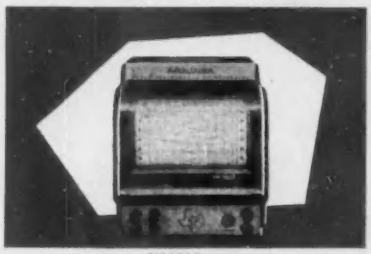
For complete information on DeJUR Potentiometers write to:

Electronic Sales Division
DeJUR-AMSCO CORPORATION
45-01 NORTHERN BOULEVARD
LONG ISLAND CITY 1, N. Y.

manufacturers of precision potentiometers for over 30 years

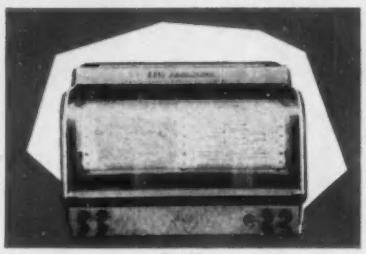
What's your application for versatile recti/riter® recorders?

TI's Applications Engineering Department invites your requests for technical assistance in OEM or end uses. Here are a few of the present applications.



SINGLE and **DUAL**

Rectilinear Galvanometric Recorders, with a wide choice of sensitivities and "recti/riter" accessories, offer the most complete ranges available for recording electrical parameters from many types of transducers.





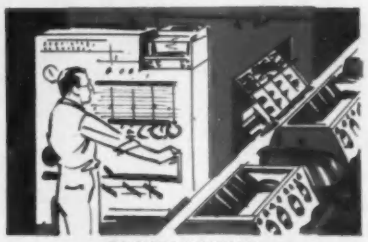
MISSILE TESTING
—a bank of "recti/riter" units record voltage frequencies and currents.



MEDICAL RESEARCH
—used with rate meters and nuclear scanners . . . also used to monitor rate of impurities in vaccines.



AIR NAVIGATION
—used to monitor ILS beams . . . also used to monitor LORAN signals.



QUALITY CONTROL
—used on numerous production lines to check sizes and contours of parts, as well as assembly rates.



METEOROLOGICAL
—records wind directions and velocities . . . also used in studies of Aurora and air glow through scintillometer counters.



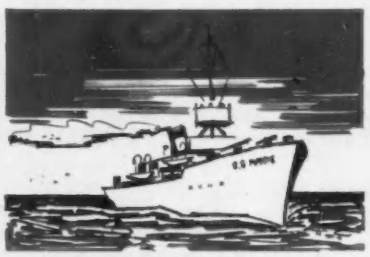
AUTOMATIC COMPUTERS
—for studying stability of electrical parameters that affect accuracy.



OIL EXPLORATION
—used in well logging as well as airborne magnetometers and scintillometers.



RADAR SPEED METERS
—used in police vehicles to visually record speed of passing motorists.



OCEANOGRAPHY
—records wave frequency and magnitude . . . also monitors underwater pressures.



ATOMIC TESTING
— used to measure radiation fall-out at test centers and nuclear installations.

TI will custom manufacture "recti/riter" recorders to your specifications for OEM use. Write for complete information.

See the complete "recti/riter" line at the I.S.A. Show!

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INCORPORATED
INDUSTRIAL INSTRUMENTATION DIVISION
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CIRCLE 74 ON READER-SERVICE CARD



Just published — bobbin core guaranteed performance limits!

We have just published new data which will light the way to ease, sureness and accuracy for the designer who works with tape wound bobbin cores.

First—and this is a "first"—we have published *guaranteed* maximum and minimum performance limits for all of our bobbin cores. Computer-type designers who would like open-circuit characteristics, guaranteed core flux and guaranteed squareness will find them all here.

Second—and this too is a "first"—we have published the first fundamental data on characteristics of bobbin cores for circuit designers. Need core total flux characteristics as related to core material? Want switching time vs drive levels? How about typical spreads of core characteristics? It's all yours.

Third—and this too is a "first"—we automatically give you test data for prototype orders. With your prototype cores come open-circuit outputs, total flux, and squareness data. You get a basic understanding of the core's characteristics under specific test conditions. More important, when you re-order production quantities, you will be able to duplicate the core around which you designed your circuit.

Last—but still a "first"—to show that we manufacture as well as publish, we have designed the first bobbin core protective cap which will permit normal potting procedures for all sizes of steel and ceramic bobbins. Our "Poly Caps" have virtually no effect on dimensions—and will not soften or deform under manufacturing or operational temperatures. We'd like to show you samples.

At what stage do you want to start? Whether it's design data, prototype data and cores, or production quantities of our "Performance-Guaranteed" bobbin cores—you can get what you need by writing Magnetics, Inc., Department CE-48, Butler, Pennsylvania.

MAGNETICS inc.

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UNCHANGED AND PROVEN

MORE THAN 30,000 SHIPPED TO CUSTOMERS OVER THE PAST THREE YEARS

ACTUAL SIZE



SERVO MOTOR	SERVO MOTOR	MOTOR GENERATOR	DC MOTOR	LINEAR TRANSFORMER	TRANSMITTER	RECEIVER	CONTROL TRANSFORMER	DIFFERENTIAL	RESOLVER
Input Power (total) 3.8 watts	Input Power (total) 5.6 watts	Generator: Input Voltage 10 v	Output Power 4.0 watts	Linearity .5%	Accuracy 7' error max.	Accuracy 30' max. error spread	Accuracy 7' error max.	Accuracy 7' error max.	Accuracy 7' error max.
Stall Torque .15 oz in min. .20 oz in nom.	Stall Torque .3 oz in min.	Output Voltage 0.13 v/1000 rpm max.	No Load Speed 20,000 rpm	Null E at EZ .015 v	Null 30 mv max.	Torque Gradient 2200 mg-mm/deg.	Null 30 mv max.	Null 30 mv max.	Null 30 mv max.
Max. Weight 29 gms.	No Load Speed 6500 rpm min.		Input Voltage 28 v DC	Phase Shift 15 deg. lead	Phase Shift 8.5 deg. lead	Input Power .54 watts	Phase Shift 8.5 deg. lead	Phase Shift 9 deg. lead	Phase Shift 11 deg. lead

LOOK TO CPPC FOR SYNCHRO PROGRESS

cppc

CLIFTON PRECISION PRODUCTS CO. INC.

Clifton Heights, Pennsylvania



Rocket engine thrust— precision measured by B-L-H Load Cells

It takes rugged, yet highly responsive, instrumentation to measure the explosive thrust of a rocket engine on test. B-L-H has solved this problem completely and accurately with its SR-4® Load Cells, mounted in a specially designed test stand of its own. The thrust of the anchored engine is exerted against the load cells. Instrumentation, which can be located at some point remote from the stand, gives moment-by-moment visual readings on dial indicators—or makes records of the performance on graphic recorders, digital printers, computers, etc.

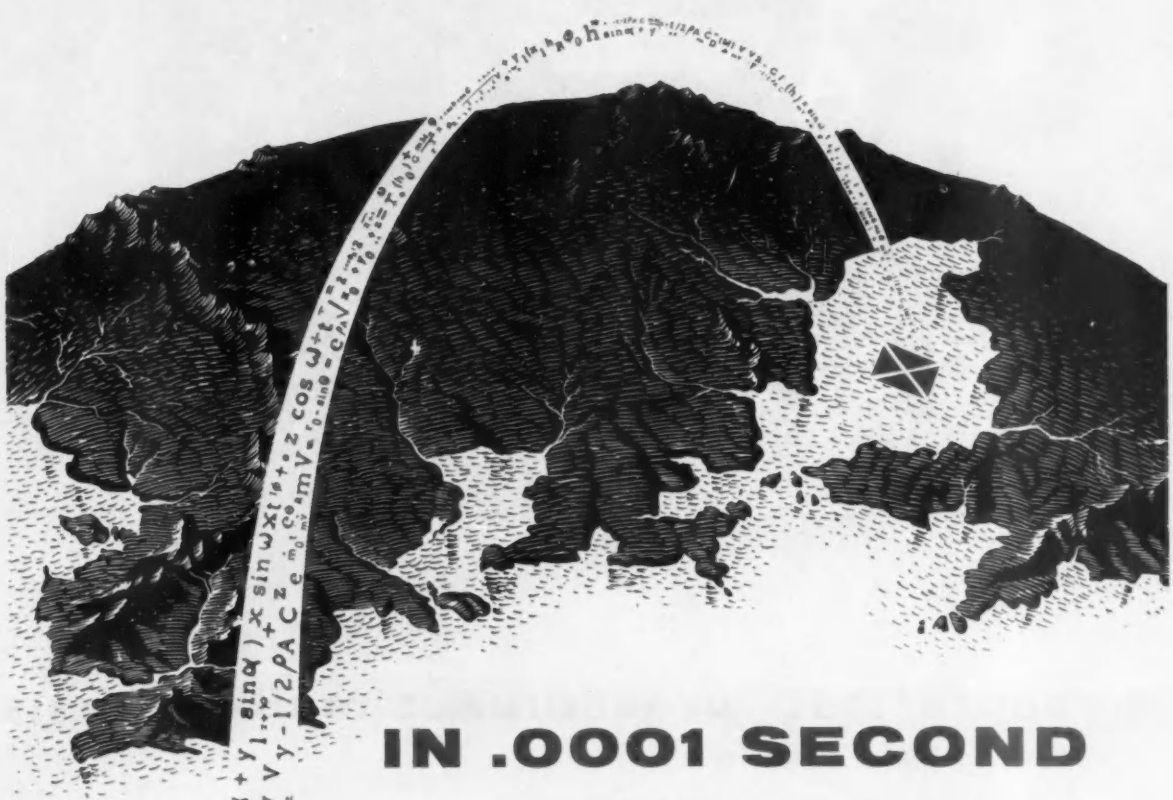
Electronic transducers offer you the answer to virtually any testing or research problems involving tension, compression, torque, etc. With appropriate instrumentation, they can also determine center of gravity, weigh loads at rest or in motion, control batch and continuous processes, and record all data required. Long-term accuracy is within $\pm 1/10\%$, repeatability within $\pm 1/20\%$.

For more information on B-L-H electronic transducers —load cells, pressure cells or torque meters—ask to have one of our field men call, without obligation. And write to Dept. 6-I for a copy of Bulletin 4300.

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Electronics & Instrumentation Division
Waltham, Mass.
SR-4® strain gages • Transducers • Testing machines

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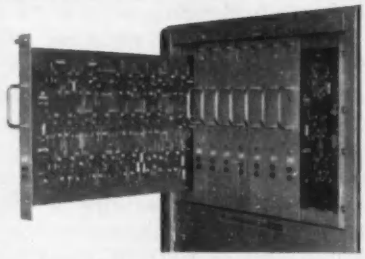
MISSILE IMPACT PREDICTION



IN .0001 SECOND

TRICE, the world's most advanced computer, saves many minutes over time currently required for ballistic missile impact prediction. TRICE modules (Integrators, Multipliers, etc.) can be assembled as a special purpose computer for dynamic systems or as a digital differential analyzer. Its incredible speed of 100,000 iterations per second *in parallel* is unaffected by the size of the problem. The first model is in operation at the U.S. Army Ordnance Missile Command, Huntsville, Ala.

Write for literature describing TRICE and its many uses: aerodynamic stability, control system stability, impact prediction, stable platform calculations, satellite orbit predictors and others.



ENGINEERING BEYOND THE EXPECTED

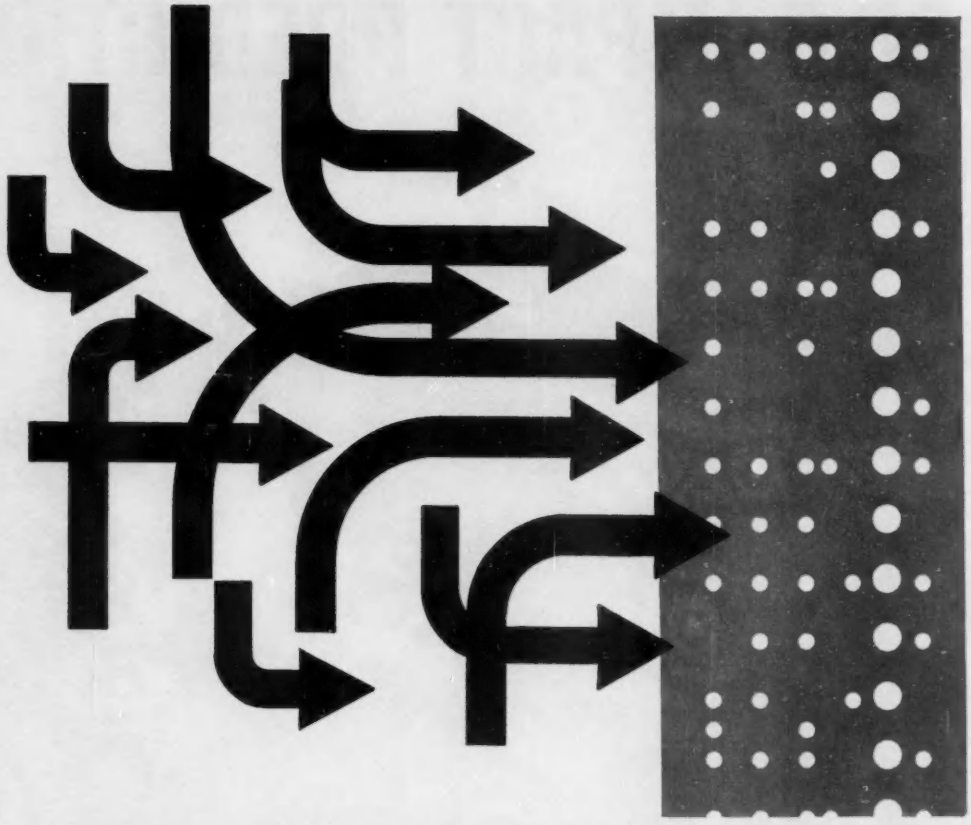
TRICE (Transistorized Realtime Incremental Computer, Expandable) is the first computer to combine the accuracy and repeatability of a digital computer with the speed, flexibility and ease of programming of an analog computer.

PACKARD-BELL COMPUTER CORP.

a subsidiary of

PACKARD BELL ELECTRONICS

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measure 250 pressures simultaneously

with a single digital transducer

NOT A SCANNING DEVICE . . . F&P's multiple pressure readout system samples hundreds of pressures *simultaneously* as often as once each minute . . . measures them with a *single* high-accuracy wide-range transducer . . . reads them out in binary or decimal format as desired.

Data can be automatically recorded in digital tabular form, fed directly into a computer. Measurements accurate to within one part in 2000 can be maintained with just a single calibration. Proved in actual use, F&P multiple pressure readout systems are measuring tens of thousands of pressures from 1 to 300 psia in the field right now.

The input section of the system accepts up to 250 pressures, measures them *simultaneously* with an F&P Press-I-Cell. The data handling section accepts measurements from one *or more* input sections, prints them out sequentially for data recording or computer input. This section also accepts other inputs—temperature, frequency, etc.—for complete, centralized data processing.

If you'd like to reduce pressure measuring costs—increase pressure measuring accuracy—get in touch with the F&P Sales Engineer nearest you. Or, write Fischer & Porter Company, 798 County Line Road, Hatboro, Pa. In Canada, write Fischer & Porter (Canada) Ltd., 2700 Jane Street, Toronto, Ontario.

FP

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Complete Process Instrumentation

Another RCA First...

A 40-Ampere* Thyratron



RCA-7086...Xenon Thyratron Forced-Air-Cooled, Negative-Control Triode Type
(shown ½ actual size)

**Anode current averaged over any period of 15 seconds maximum*

Again, RCA leads the way in industrial tube development—with a husky thyratron designed for applications in which high peak currents are required or in which high average or rms currents are demanded. Here are just a few of the big jobs the RCA-7086 can do:

- *It can deliver a maximum peak anode current of 400 amperes in intermittent service or 160 amperes in continuous service.*
- *In a typical X-ray tube control circuit, two tubes can control a current of 280 amperes rms through the primary of the power transformer (supplying high voltage to the X-ray tube).*
- *In welding service utilizing a single-phase inverse-parallel circuit, two tubes can provide a maximum average ac output of 130 kva.*
- *In inverter equipment, two tubes can deliver up to 15 kva average power.*
- *In speed control of dc motors, two tubes will control 220-volt dc motors rated up to 20 horsepower.*

The 7086 has a high commutation factor, a relatively short dionization time, and a negative-control characteristic that is essentially independent of ambient temperature over the wide range −55° to +75°C because of its xenon gas content.

RCA-7086 DATA

Filament volts	2.5
Filament Amperes	92
Air Flow (cfm)	60
Supply Frequency (cps)	25 to 60

	Continuous Service	Intermittent Service
Peak Anode Volts:		
Forward	650 max.	650 max.
Inverse	650 max.	650 max.
Anode Amperes:		
Peak	160 max.	400 max.
Average	40 max.*	7 max.**

*Averaged over any period of 15 sec. max.
**Averaged over any period of 36 sec. max.

Your RCA Field Representative will be glad to discuss application of this new thyratron with designers of power-control equipment. For a technical bulletin on the RCA-7086, write RCA Commercial Engineering, Section 1-56-Q Harrison, New Jersey.

RADIO CORPORATION OF AMERICA
Electron Tube Division **Harrison, N. J.**

MICRO SWITCH Precision Switches

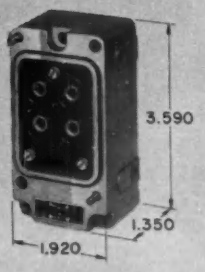


PULL OUT



PLUG IN

18 PA1 Terminal Enclosure—is common to all actuator assemblies in the "200LS" series. Can be mounted from front, back or either side.





Actuator plugs into terminal enclosure—contains all moving mechanical and electrical parts.

NEW...

"Plug-in Limit" Switch cuts costly downtime

Compact sealed enclosures with choice of 6 actuators meet wide range of industry needs

Here's a precision limit switch you can replace complete in 20 seconds! Downtime is all but eliminated!

The switch enclosure of this new "Plug-in Limit" switch, in any of six actuator styles, plugs into the terminal enclosure like a radio tube . . . is precisely positioned by dowel pins and secured by two No. 10 screws. Together, the two parts form a complete unit, sealed against oil, water, dirt and dust.

The "Plug-in Limit" is two-circuit double throw. Electrical rating is 10 amps. 120, 240, 480 vac; ½ H.P. 120 vac; 1 H.P. 240 vac; 0.8 amp. 115 vdc; 0.4 amp. 230 vdc; 0.1 amp. 550 vdc. Pilot duty rating is 600 vac max. Meets NEMA Industrial Control Standards.

Authorized distributors everywhere maintain stocks. MICRO SWITCH technical specialists are available at the sales office near you. For details of the new "200LS" Series, send for Catalog 83.

—•—

MICRO SWITCH...FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls, Ltd., Toronto 17, Ont.

—•—

The two-word name MICRO SWITCH *is* NOT *a generic term. It is the name of a division of Honeywell.*



201LS3 Adjustable Arm Rotary Actuator—roller lever arm is adjustable to any point in a 2½-inch range. Head assembly can be positioned to any of 4 sides of switch. Actuating direction and operating point are adjustable.



208LS1 Coil Spring Actuator—flexible spring actuator for multi-direction operating motion



201LS10 Rod Actuator—provides light actuating force. See adjustability details under 201LS1 below



205LS1 Roller Plunger Actuator—adjustable at 90° angles



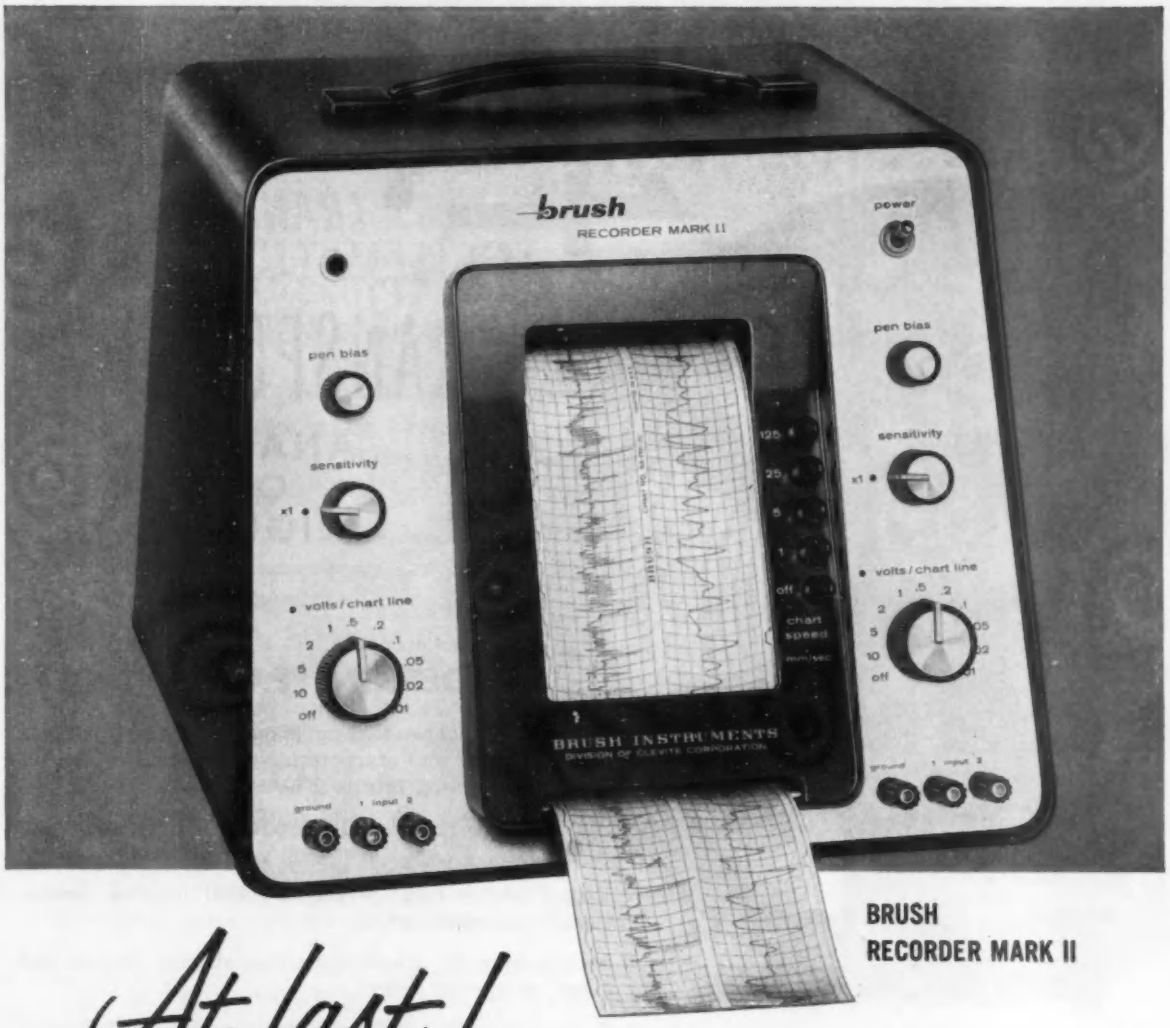
202LS1 Push Plunger Actuator—for in-line actuating motion



201LS1 Roller Arm Actuator—field adjustable for actuation clockwise, counter-clockwise, or in both directions. Arm is adjustable through 360°. Head can be faced in any of four directions.

Honeywell
MICRO SWITCH PRECISION SWITCHES

Look for the name of MICRO SWITCH *Authorized Distributors in the Yellow Pages*



BRUSH
RECORDER MARK II

At last!

New Oscillograph Package

AS "IDIOT-PROOF" AS YOU'VE HOPED FOR

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- **Permanently calibrated**
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- **"White glove" writing system**

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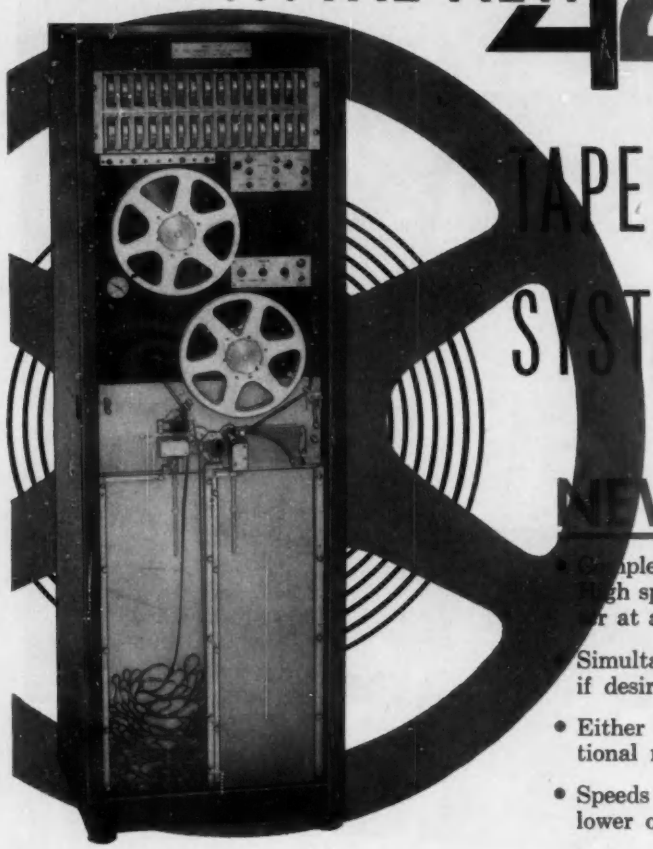
CIRCLE 81 ON READER-SERVICE CARD

Announcing

...THE NEW 424 ..... FULLY TRANSISTORIZED

TAPE TRANSPORT SYSTEM

ANALOG OR DIGITAL



RECORD

STORE

REPRODUCE

Model 424 as a closed loop system—Model 424R with supply and take-up reels. Detailed information and complete specifications are contained in Bulletin H-424, available upon request.

NEW DESIGN FEATURES:

- Completely independent capstans and storage baskets. High speed (2 ms) start-stop. No resonance or reel jitter at any cycling rate to 150/second.
- Simultaneous record and reproduce at different speeds if desired.
- Either station can operate as closed loop or conventional reel transport.
- Speeds from 7½ to 60 ips either station (higher and lower on special order).
- Each storage bin adequate for more than 250 feet of tape.
- Head to head spacing (Station 1 to Station 2) less than 4 inches.
- Automatic (on command) transfer of message start from Station 1 to Station 2.
- Very low flutter and wow.
- Tape tension controlled by unique vacuum pressure pads.
- Tape widths from ¼" to 1" (up to 2" on special order).
- Completely transistorized.
- Modular construction.
- Low power demand.

THE DGC HARE COMPANY

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A SUBSIDIARY OF SANGAMO ELECTRIC COMPANY

(Advertisement)

air circuitry:

a new term of importance to control engineers.

Air has come of age as a control medium. No longer is it confined to the simple jobs of pushing a clamping device, moving a lever, or blowing chips. No longer is an air circuit just a valve, reservoir, and cylinder. Today the most complex of industrial control problems can and are being solved efficiently with air.

Today, pneumatic circuits can be interconnected. They can be set to control a complex sequence of operations *automatically*. They can be combined with electrical circuits. There is *no* control problem you have that can't be solved successfully with air.

The new role that pneumatic control can play in industrial operations demands a new way of thinking about air control. It demands a new way to describe control by air—a new name that suggests some of its limitless control possibilities. That's why Westinghouse Air Brake Company is now using the term "air circuitry" to describe the application of air control to automation.

Westinghouse Air Circuitry, we realize, has to be more than *just as good* as your present means of control. It has to offer you *extra advantages*. And it does.

Chief among these is its extreme simplicity. The devices themselves are uncomplicated mechanical devices. They have few moving parts. They are easy to service by any mechanic. The circuit connections are made with pipe—and what could be simpler than that!

This extreme simplicity brings with it other important "pluses" for air circuitry. The simple equipment is unusually reliable—there are few moving parts to wear out or get out of adjustment. The devices are sturdy and durable. They require very little maintenance. What maintenance there is can be handled without the services of highly trained technicians.

Above all, remember: no means of control is as *safe* as air.

Air circuitry can help you simplify your control problems. It can help you get accurate answers to your automation problems on any industrial machine . . . in any industrial process. And Westinghouse Air Brake Company can help you with the engineering of a suitable system. Westinghouse has been in the control engineering business for 80 years now. It has been at the forefront of the development and improvement of air control equipment and its applications.

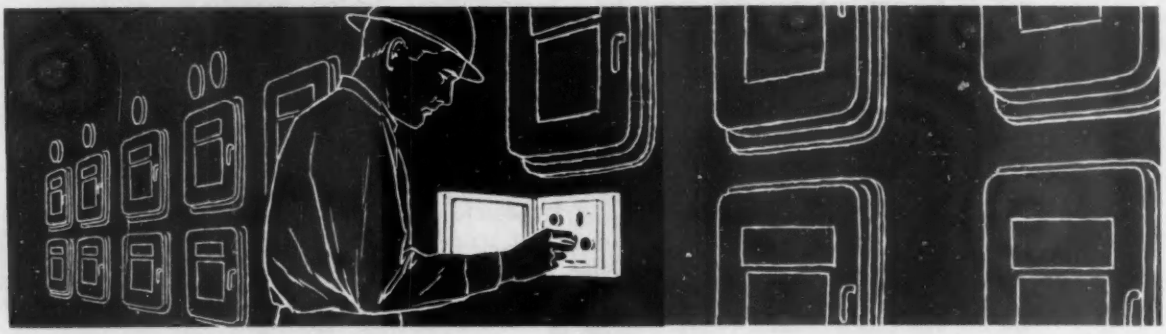
For more information on Westinghouse Air Circuitry—how it has helped other companies, how it can help you—write for your copy of "Basic Pneumatic Control," or call our nearest sales office.

WESTINGHOUSE AIR BRAKE COMPANY, INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PA.

CIRCLE 83 ON READER-SERVICE CARD

Here's the heart of your process control center...

CEC's process chromatograph



Put your finger on the simplest, most reliable analytical instrument in chemical and petroleum processing: CEC's 26-202 Process Chromatograph. This is the completely transistorized, trouble-free system that's improving quality control and solving processing problems throughout industry.

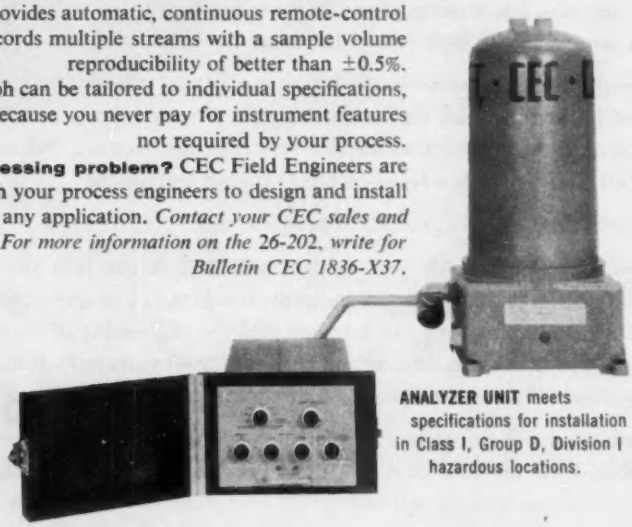
Operating personnel depend on its rapid response and precise reproducibility to take the guesswork out of process adjustments. The 26-202 provides automatic, continuous remote-control monitoring...records multiple streams with a sample volume reproducibility of better than ±0.5%.

This basic chromatograph can be tailored to individual specifications, actually costs less because you never pay for instrument features not required by your process.

What is your processing problem? CEC Field Engineers are available to work with your process engineers to design and install complete systems for any application. *Contact your CEC sales and service office today. For more information on the 26-202, write for Bulletin CEC 1836-X37.*

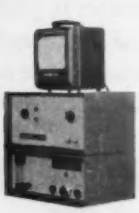
TYPICAL PROCESS APPLICATIONS

- Alkylation
- Butadiene Processing
- Natural Gas and Gasoline Production
- Annealing Furnaces
- Ammonia Synthesis
- Chlorine Production
- Flue Gas Analysis
- Catalytic Reforming
- Polymerization
- Catalytic Cracking
- Isomerization



CONTROL UNIT can be located at least 500 feet from the Analyzer Unit.

ANALYZER UNIT meets specifications for installation in Class I, Group D, Division I hazardous locations.



FOR THE LABORATORY... CEC's versatile 26-201A Laboratory Chromatograph guarantees speed and superior reproducibility. Easily operated by untrained help.

Analytical & Control Instrument Division CEC

Consolidated Electrodynamics

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FOR EMPLOYMENT OPPORTUNITIES *with this progressive company, write Director of Personnel.*

Foxboro introduces

ELECTRONIC CONSOTROL* INSTRUMENTATION

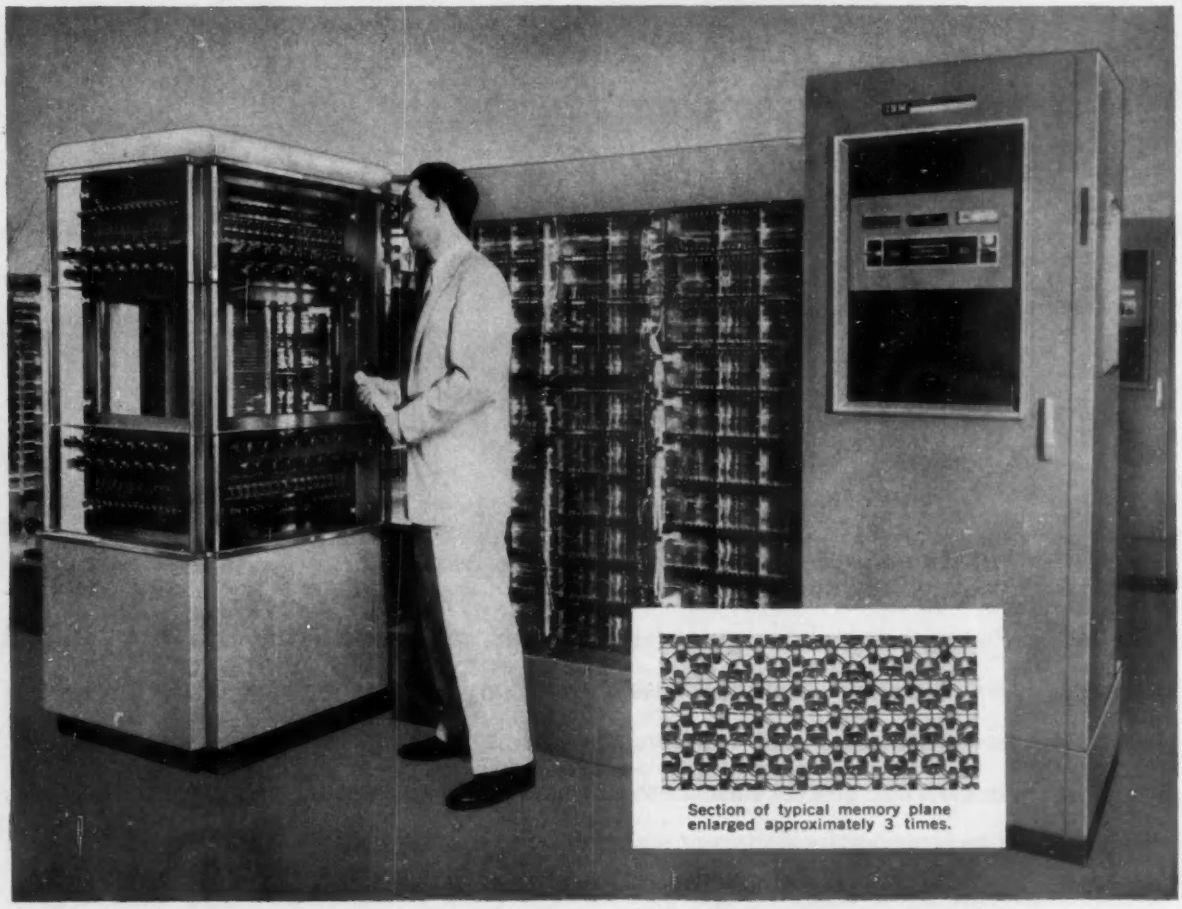
On September 15th, at the I.S.A. Show in Philadelphia, The Foxboro Company will unveil Electronic Consotrol Instrumentation... counterpart of its world-famous pneumatic Consotrol line. ✓ ✓ ✓ Including a complete range of transmitters, indicators, recorders, controllers and valve operators, Electronic Consotrol Instrumentation covers every function in the control loop... provides advanced-design electronic control systems for all modern requirements. ✓ ✓ ✓ In these systems, process measurements such as temperature, pressure, flow and level, are converted to a proportional current signal at the transmitter. Long-distance transmission is instantaneous... over unshielded lines... to small-case, Consotrol panel-type receivers at the central control station. ✓ ✓ ✓ The full story on this major Foxboro contribution to better process control will be presented in Booth No. 12-72 at the I.S.A. Show. Or, write for comprehensive Bulletin 21-10. The Foxboro Company, 369 Norfolk Street, Foxboro, Mass.

*Reg. U.S. Pat. Off.

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Foxboro makes a better instrument...
or Foxboro doesn't make it

Another Application for FERRAMICS®



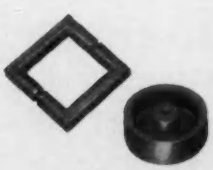
Ferramic® Cores help IBM Sage Computer Perform Amazing Feats of Memory

General Ceramics Magnetic Memory Cores play an important role in the reliable functioning of the Sage Computer. G-C engineers developed rectangular hysteresis loop ferrites and worked closely with Lincoln Laboratories at MIT and IBM to perfect toroids with the required magnetic properties for this vital defense system.

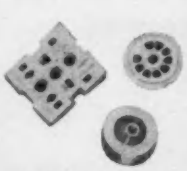
These dependable components provide increased speed and accuracy for computers and automatic controls. General Ceramics cores and completely assembled memory planes are available for automation systems. For complete information write today to General Ceramics Corporation, Keasbey, New Jersey—Dept. CE.

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Industrial Ceramics for Industrial Progress...Since 1906


FERRAMIC CORES


MAGNETIC MEMORY CORES AND PLANES


PRECISION STEATITES

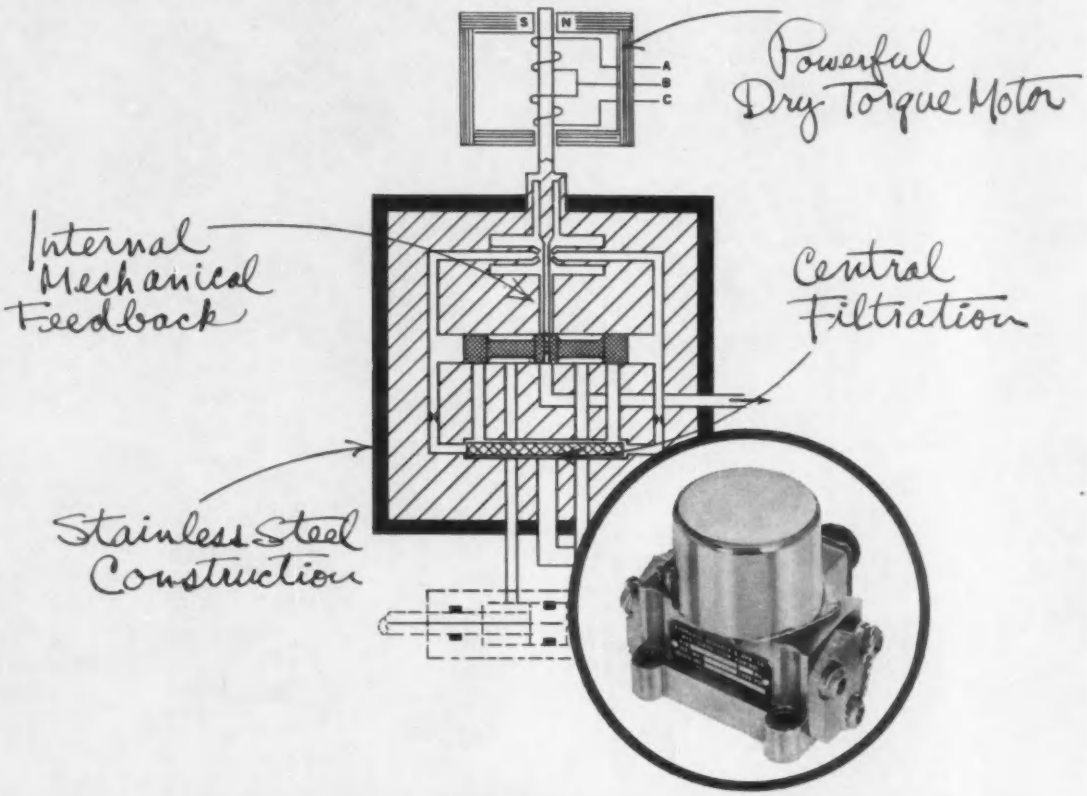

"ADVAC" HIGH TEMPERATURE SEALS


SOLDERSEAL TERMINALS

HYDRAULIC RESEARCH

*The originator of the Dry Torque Motor Servo**

Presents



A NEW SERVO TRANSDUCER FOR HIGH PERFORMANCE CONTROL

Designed for Electro-Hydraulic flow, pressure, or power control up to 40 Hydraulic horse power, with performance peaks never before obtained in a production unit.

EXCEPTIONAL NULL BALANCE, NO ADJUSTMENT REQUIRED, AND ESSENTIALLY UNAFFECTED BY:

VIBRATION to 100g's
TEMPERATURES −65° to +450°F
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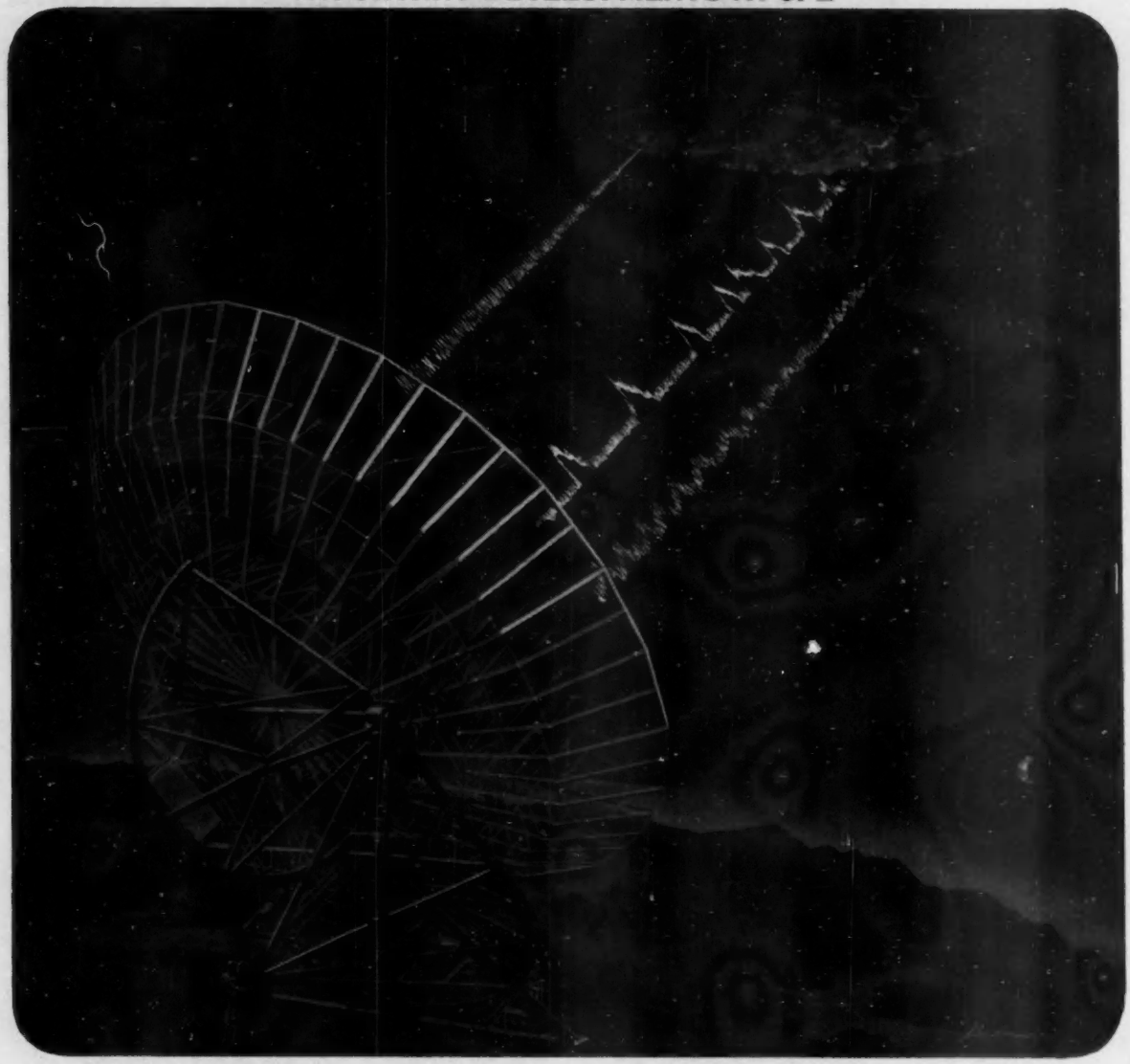
Write for Complete Data

HYDRAULIC RESEARCH AND MANUFACTURING COMPANY
Subsidiary of Bell Aircraft Corp.
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*Thousands of the original Dry Torque Motor servo valves are now in use by aircraft, propulsion and missile manufacturers.

CIRCLE 87 ON READER-SERVICE CARD

IMPORTANT DEVELOPMENTS AT JPL



PIONEERS IN EARTH-SPACE COMMUNICATIONS

The exploration of outer space will take a new step forward with the completion of the new giant radio antenna being installed by JPL near Barstow, California. This huge "dish," 85 ft. in diameter, will enable the Laboratory scientists to probe still farther into space problems.

Information thus obtained and combined with lessons still being learned from the successful Army "Explorer" satellites, will provide invaluable basic data for the development of communication systems to serve space exploration programs. Long range communication will begin as a one-way link from space to earth, developing later into tracking and communicating with lunar vehicles at far greater ranges.

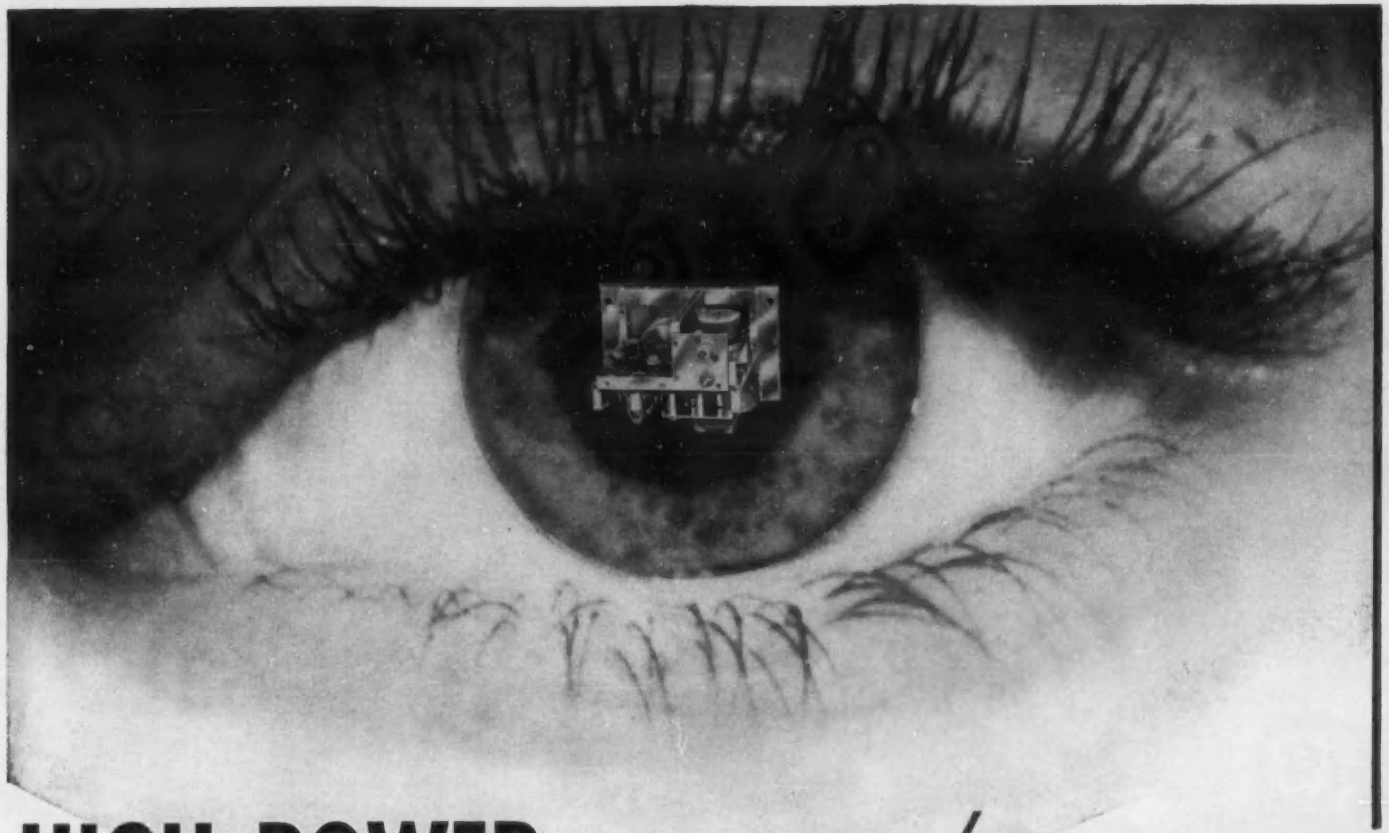
This activity will be part of a great research and development program to be operated jointly by JPL and the United States Army Missile Command.

jpl

JET PROPULSION LABORATORY

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HIGH POWER

in Small Packages

Unhampered by traditional thinking, TELECHROME engineers have developed an entirely new concept in telemetering equipment — unequalled in compactness, ruggedness and dependability. **Write for Specifications & Details**

FOR MESSAGES FROM OUTER SPACE

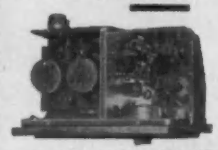
TELEMETERING TRANSMITTERS

by

TELECHROME MFG. CORP.

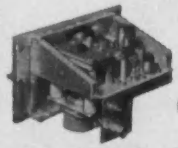
The Nation's Leading Supplier of Color TV Equipment

Direct FM Transmitters Crystal controlled 215-235 megacycles. 125kc deviation.



Model 1462

6" x 4¼" x 3⅜" 50 to 80 Watts



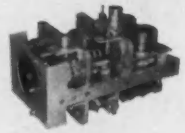
Model 1463

5 1⁵⁄₃₂" x 3 1⁹⁄₁₆" x 4" 15 to 30 Watts



Model 1472

4" x 1.5" x 2.7" 2 Watts



Model 1466A
6.5" x 4" x 3.25" RF Amplifier
2 watts in — 100 watts out

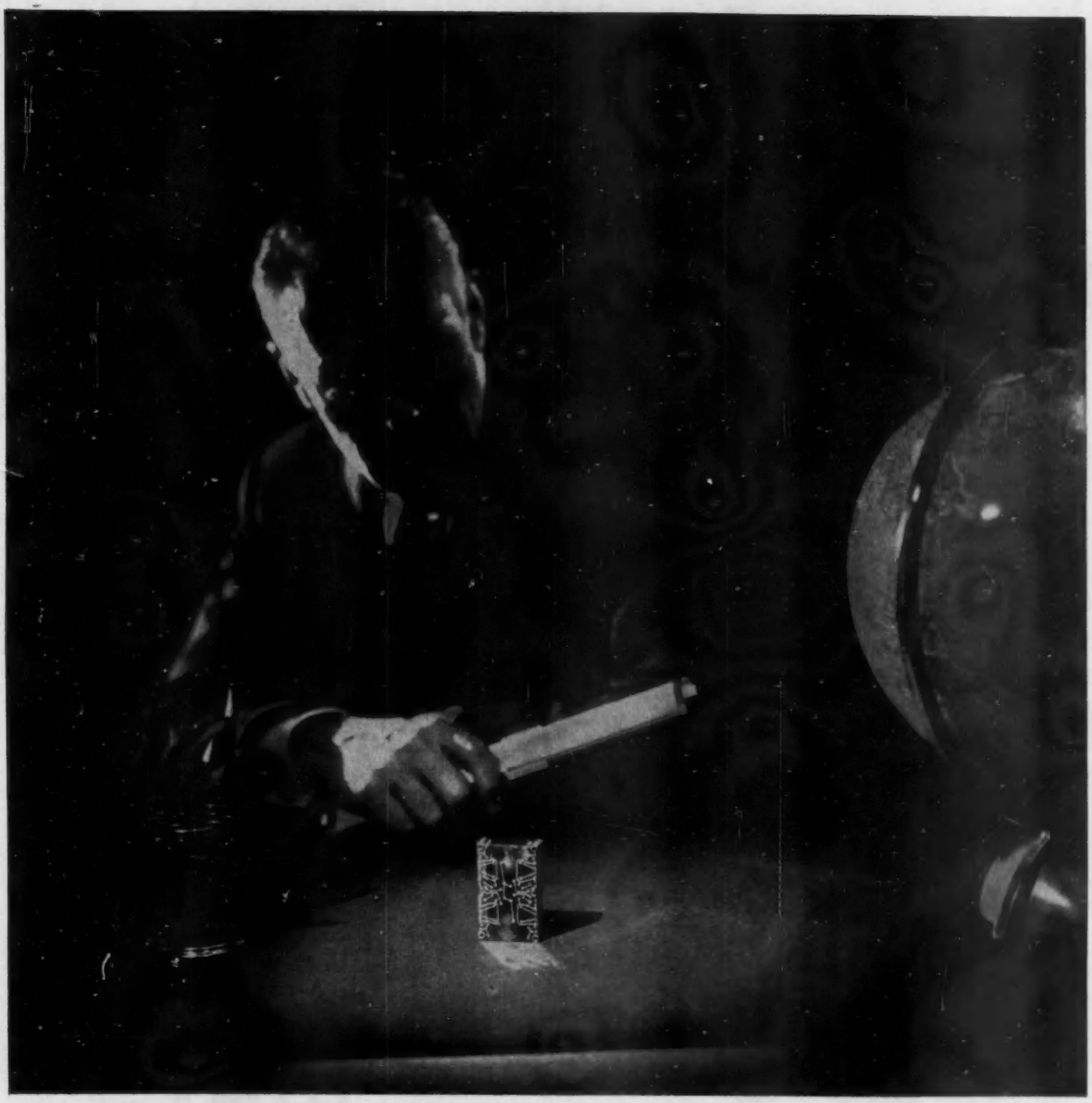
SUB-CARRIER OSCILLATOR.



Model 800C — 1.5" x 1.9" x 2.45"
Deviation stability ±1% of band width. Deviation linearity less than 1% of band width under all conditions measured from a straight line drawn between end points.

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It takes brains . . .

to guide a missile . . . mechanical brains, that is, like this tough but tiny *ARMA* digital computer module. *ARMA* has put a great many brains to work designing a fully transistorized and miniaturized digital computer, a critical part of *ARMA*'s all-inertial guidance system for the Air Force ICBM . . . Titan.

. . . and now the Atlas!

More brains, the human kind, are now needed for *ARMA*'s inertial role in the Atlas ICBM Program. Specialized senior engineering and technical management positions with excellent growth potential are now available. Write to *ARMA* . . . Professional Personnel, Garden City, N. Y. Prompt, convenient, confidential interviews.

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AMERICAN BOSCH ARMA CORPORATION



LINEAR MOTION POTENTIOMETERS



ACCELEROMETERS



PRESSURE TRANSDUCERS

1355 PROVED POTENTIOMETER INSTRUMENT DESIGNS ---READY TO SAVE YOU TIME AND MONEY

Here are 3 of our 1355 ways to help you avoid costly "specials"... ready-made answers to thousands of problems in measuring linear displacement, pressure and acceleration. Bourns may have precisely the model you need – or one that can be quickly modified to fit your requirements.

More than 10 years of experience in design, development and manufacturing back up the instruments you buy from Bourns. These precision wirewound potentiometer instruments have proved their quality repeatedly in the nation's top missile and aircraft systems.

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Write for new Instrument Brochure

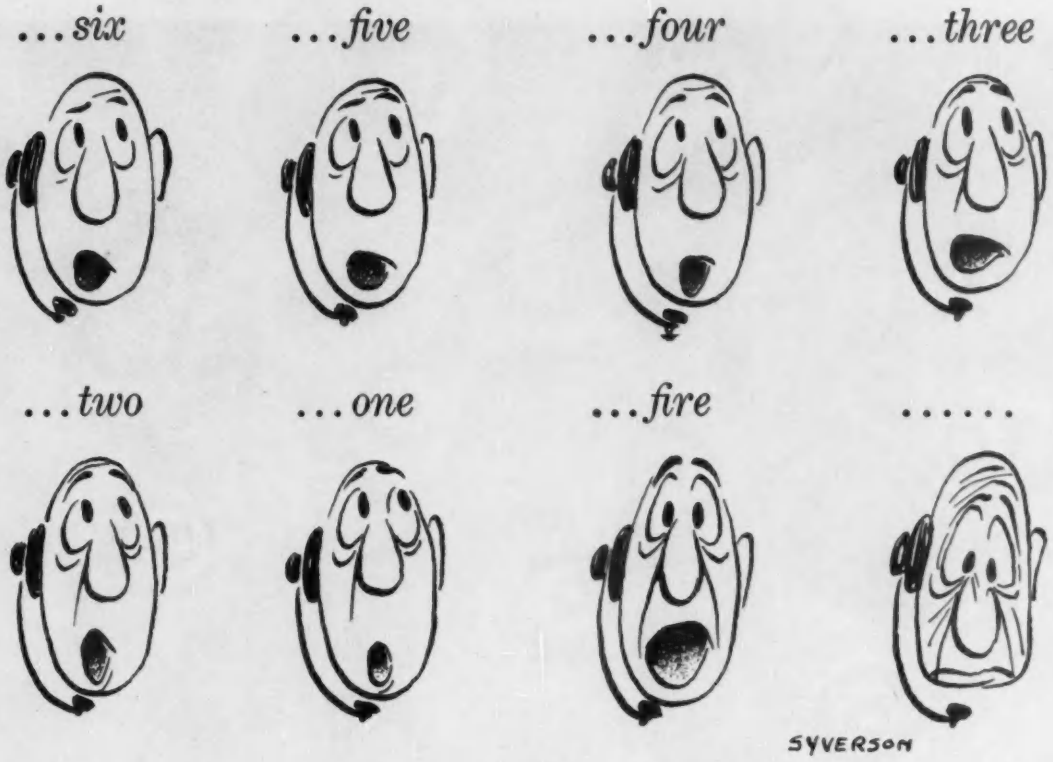


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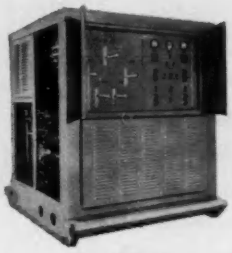
ORIGINATORS OF TRIMPOT® AND TRIMIT®
PIONEERS IN POTENTIOMETER TRANSDUCERS FOR POSITION, PRESSURE AND ACCELERATION

CIRCLE 91 ON READER-SERVICE CARD



When the target is space and a million dollars' worth of missile rests idly on the ground—not even a long countdown helps. In a showdown situation, the successful shoot depends on the "go, no-go" type of test that pinpoints the trouble.

NEXT TIME...LOOK TO INET FOR PRECISE GROUND POWER



This INET 400-cycle ground power unit was tailor-made for the Atlas. In meeting all of Convair's specifications for pre-flight calibration of electrical systems, the unit operates in parallel with the missile's power system and provides remote control regulation. Frequency regulation is ±0.2%. With shock load equal to a third of rated output, frequency recovers to ±0.2% in 0.15 seconds. Voltage regulation is ±0.5% with recovery time at 0.30 seconds.



Missile men desiring a special reprint of the above cartoon should write to "Count-down", c/o Inet Division of Leach.

INET DIVISION LEACH CORPORATION

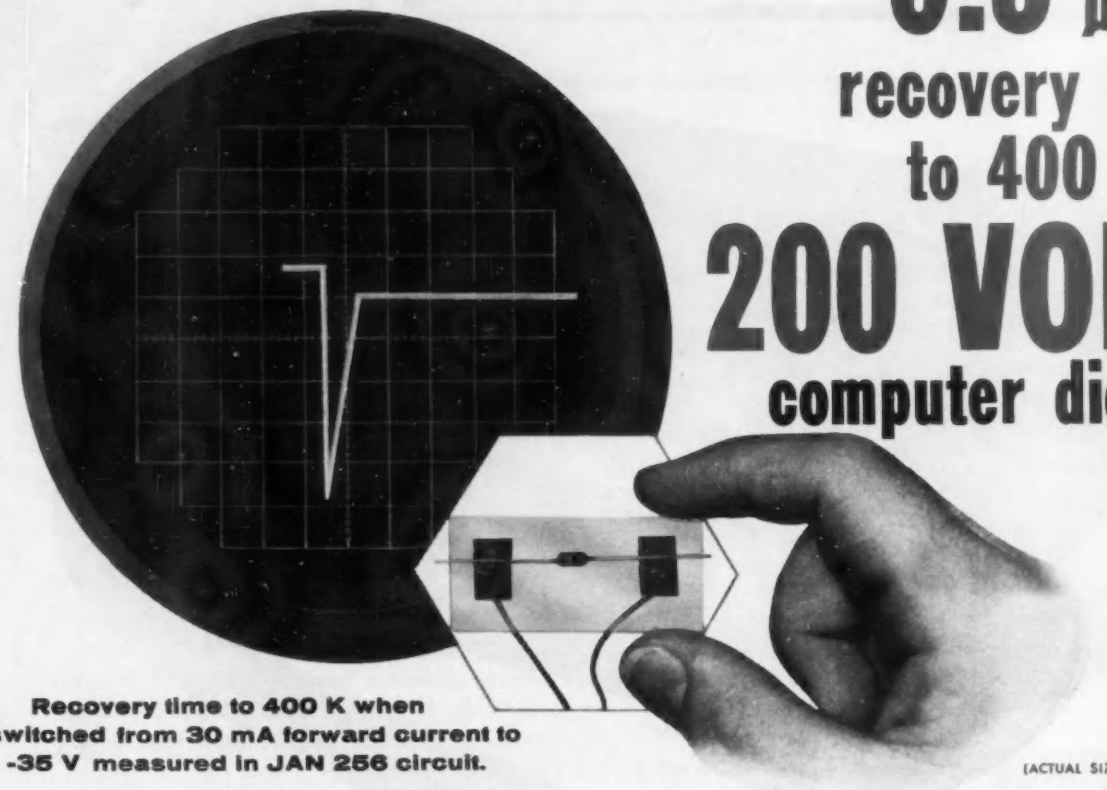
18435 SUSANA ROAD, COMPTON, CALIFORNIA

DISTRICT OFFICES AND REPRESENTATIVES IN PRINCIPAL CITIES OF U. S. AND CANADA

T/I diffused silicon

0.3 μ sec recovery time to 400 k

200 VOLT computer diodes

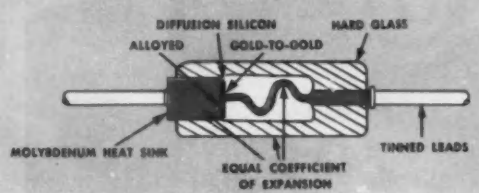


Recovery time to 400 K when switched from 30 mA forward current to -35 V measured in JAN 256 circuit.

(ACTUAL SIZE)



cutaway view of TI glass diode



TI diffused silicon computer diodes give you 0.3 μ sec maximum recovery time at 400 K with PIV ratings to 200 volts.

For your computer applications, TI hard glass diodes provide 100 mA average rectified forward current at 25°C. All units are rated to meet military requirements, and provide fast recovery, higher conductance ratings, and shock-proof reliability.

Check the characteristics below and specify TI diodes for all your computer applications.

Also in this same glass package, TI general purpose diodes

max ratings	1N645	1N646	1N647	1N648	1N649	
PIV	225	300	400	500	600	V
I_O	400	400	400	400	400	mA
I_O	150	150	150	150	150	mA
i_f	1.25	1.25	1.25	1.25	1.25	amp
P	600	600	600	600	600	mW
I_{DC}	3	3	3	3	3	Amp
T_A	—65 to +150					°C
specifications						
V_Z	275	360	480	600	720	V
LI_b	0.2	0.2	0.2	0.2	0.2	μA
LI_b	15	15	20	20	25	μA
E_b	1.0	1.0	1.0	1.0	1.0	V
C	9	9	9	9	9	μμf

maximum ratings	1N659	1N660	1N661	
Peak Inverse Voltage at —65 to +150°C	50	100	200	V
Average Rectified Forward Current at +25°C	100	100	100	mA
Average Rectified Forward Current at +150°C	30	30	30	mA
Recurrent Peak Forward Current at +25°C	320	320	320	mA
Operating Temperature, Ambient	—65 to +150			°C
Altitude	100,000			ft
specifications				
Minimum Breakdown Voltage at +100°C	60	120	240	V
Maximum Reverse Current at PIV at +25°C	5	5	10	μA
Maximum Reverse Current at PIV at +100°C	25	50	100	μA
Maximum Voltage Drop at I_O = 6mA at 25°C	1	1	1	V
Maximum Reverse Recovery Time*	0.3	0.3	0.3	μsec
Typical Capacitance at —10V at 1 mc	2.7	2.7	2.7	μμfd

Recovery time to 400K when switched from 30 mA forward current to —35V. Measurement made with a Hauman ND-1 standard pulse recovery test set approved by JETEC-14 and described in JAN-256.

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CIRCLE 93 ON READER-SERVICE CARD

Two *NEW* Teletype tape



TAPE PUNCH

Teletype Model 28
Typing Reperforator

TAPE READER

Teletype Model 28
Transmitter-Distributor

units speed work, cut costs

More uniform work loads, greater accuracy, lower cost, faster handling, greater operating efficiency in:

• sales, sales analysis, warehousing, accounting, purchasing, production control, shipping, receiving, manufacturing;

• communications, data processing, automation and paperwork simplification.

These new punched tape units offer you the opportunity of extending your communication and business systems into new departments at a relatively low cost. They can be used individually . . . or in combination with other Teletype equipment . . . or with such business machines as computers, calculators and card punches.

All advanced Teletype Model 28 features —operation at 100 words per minute, handsome styling, compactness, extremely quiet operation, modular design, metal clutches that require oiling only once or twice a year.

TAPE PUNCH • The Teletype Model 28 Tape Punch is a receiving unit—for message relaying in communication systems . . . integrating data from several sources into a single tape . . . monitoring . . . by-product tapes.

Features and Specifications:

1. Receives incoming sequential signals and translates them into punched code combinations in tape.
2. Types corresponding characters on the tape.
3. Provides facility for parallel-wire output of incoming signals, with simultaneous punching of tape, for control of external equipment.

Speed 100 wpm (or lower speeds where required for compatibility with existing systems). Produces chadless (partially punched) 5-level code tape, 11/16" wide. Prints on tape. Dimensions, a compact 9½" high, 13" wide, and 14⅛" deep.

TAPE READER • The Teletype Model 28 Tape Reader is a transmitting unit. When punched tape is fed into the unit, it "reads" the code combinations and automatically sends them to their destination. Serves as a sending unit in communications systems . . . read-out device for business machines . . . control mechanism for automated equipment.

Features and Specifications:

1. Translates code in perforated tape into electrical impulses for sequential transmission.
2. Translates code in perforated tape into electrical impulses for parallel-wire transmission.
3. Receives electrical impulses from external parallel-wire source and translates them for sequential transmission.

Operates at 100 wpm (lower if required). Handles chadless or fully punched tape.

MORE INFORMATION • For descriptive literature on the new Punch and Reader—or other units in the Teletype Model 28 line—please write to Teletype Corporation, Dept. 20J, 4100 Fullerton Avenue, Chicago 39, Illinois.



MODEL 28 PRINTER, RECEIVE ONLY



MODEL 28 PRINTER, SEND & RECEIVE



MODEL 28 ASR COMPOSITE SET

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

CIRCLE 94 ON READER-SERVICE CARD

Read directly

1μμa

and

1μv

with 10 times previous accuracy!

Drift less than ± 2 μv; noise less than 0.2 μv!

New -*hp*- 425A Microvolt-Ammeter

now makes these difficult measurements quickly and easily!

ENGINEERING

Minute dc potentials, difference voltages, nulls

Resistances from milliohms to 10 megmegohms*

Use with Esterline-Angus, other recorders

PHYSICS, CHEMISTRY

Grid, photomultiplier currents

Ionization levels in vacuum

Thermocouple potentials

Voltaic currents in chemicals

MEDICINE, BIOLOGY

Voltages in living cells

Nerve voltages

Voltages in plants, seeds

*with external dc source.

hp is announcing more than 30



The all-new -*hp*- 425A Microvolt-Ammeter will provide engineers, physicists, chemists and physiological scientists with one compact, direct-reading instrument measuring minute voltages and currents with speed, simplicity and 10 times the sensitivity of the complex equipment arrays previously required.

Very careful engineering, including heavy filtering against ac signals and substitution of a unique photoelectric chopper for the conventional mechanical vibrator, has resulted in performance heretofore unobtainable. The long-term drift of the 425A is less than 2μv and internal noise is less than 0.2 μv.

Conservative electrically, Model 425A includes every conceivable assurance of safety, accuracy and dependability. For example, momentary overloads of 1,000 volts cause no damage; and the new pickup probe is specially designed to minimize thermocouple and triboelectric effects. The meter provides constant polarity indication.

The new -*hp*- 425A also may be used to measure a wide range of resistances. Milliohms may be measured by using a battery and series resistor as a constant current source. Higher resistances may be measured with higher voltages; a 100 volt supply allows the 425A to measure accurately up to 10 megmegohms.

Call your -*hp*- representative now for demonstration on your bench; or, write for details.

HEWLETT-PACKARD COMPANY
4582H PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.
Cable "HEWPACK" • DAvenport 5-4451
FIELD REPRESENTATIVES IN ALL PRINCIPAL AREAS

SPECIFICATIONS

MICROVOLT-AMMETER

Voltage Range:	Positive and negative voltages from 10 μv full scale to 1 v full scale in an eleven step, 1, 3, 10 sequence.
Current Range:	Positive and negative currents from 10 $\mu\mu$a full scale to 3 ma full scale in an eighteen step, 1-3-10 sequence.
Input Impedance:	Voltage Ranges: 1 megohm $\pm$5%. Current Ranges: Depends on range, 1 megohm to 0.33 ohm.
Accuracy:	Within $\pm$3% of full scale.
AMPLIFIER	
Frequency Range:	dc to 0.2 cps.
Gain:	100,000 maximum.
Output:	0 to 1 v for full scale reading, adjustable.
Output Impedance:	10 ohms, shunted by 1000 ohm potentiometer.
Noise:	Less than 0.2 μv rms referred to input.
Drift:	After 15 minute warm-up, less than $\pm$2 μv per hour referred to the input.
Power:	115 v $\pm$10 v, 230 $\pm$20 v, 60 cps, 40 watts.
Dimensions:	Cabinet Mount: 7½" wide, 11¼" high, 14" deep.
Weight:	Net 20 lbs.
Price:	$500.00. -*hp*- 425AR (rack mount) $505.00. -*hp*- 425A (cabinet) $500.00.

Data subject to change without notice. Prices f.o.b. factory.

basic new instruments in 1958

IT'S NEW!...IT'S FASTER! IT'S MORE ACCURATE!



ELECTRONIC DIGITAL VOLTMETER — EDVM

Noiseless — Transistorized — No Stepping Switches. Identifies point in problem being read. Read-out in .005 seconds. Accuracy of 0.01%. Moving parts replaced by solid state circuits.

AUTOMATIC DIGITAL INPUT-OUTPUT SYSTEM — ADIOS

Servo-set attenuators, pre-programmed on punched paper tape, permit four times faster pot setting. Two seconds per set with 0.01% accuracy.

PATCH-BOARD CLUTTER ELIMINATED

Countless studies at EAI Computation Centers dictated modular concept adopted in new, oversize Patch Panel design. Logical grouping of component connections replaces long patch cords with compact bottle plugs. "Hold" and "Reset" control now provided for individual amplifiers. Connections for 3,450 terminations facilitate maximum future expansion.

AUTOMATIC EXTENDED READ-OUT — AERO

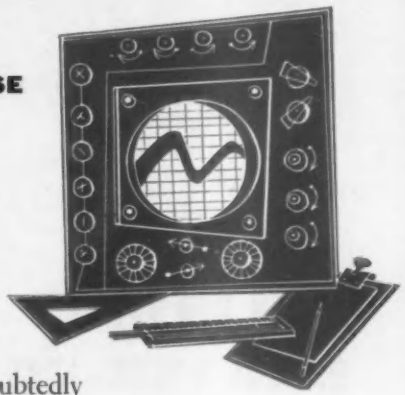
Problem read-out points selected by Push Button Control. Read-out Time — Instantaneous on EAI's new EDVM. Print-out — Four readings per second on new EAI Printer.

The 231-R Computer provides more computing at less cost, in less space than ever before achieved in analog computer design. For complete details, contact Electronic Associates, Inc., Long Branch, New Jersey, Dept. CE-9.

ELECTRONIC ASSOCIATES *Incorporated*

• • • • • MANUFACTURERS OF PACE PRECISION ANALOG COMPUTING EQUIPMENT

LONG BRANCH. NEW JERSEY • TEL. CAPITOL 9-1100



The Whys of Recorded Information Control

Fastest expanding area of program control is undoubtedly in the application of recorded information—curve followers, punched cards, punched tape, and magnetic tape—as input media. Although still in its infancy, recorded information control calls for intriguing design. But it's highly practical, too.

Five reasons

In a study of 25 recent applications, five basic reasons stood out to explain why recorded information control was used. In some, automatic control of the equipment would not have been possible without such an input. The five reasons:

- to simplify a labor problem
- to increase capacity of the control system
- to increase output
- to provide versatility at economic cost
- to improve quality of product

1. Downgrade labor

Reducing direct labor hours is only one saving possible with this kind of control. In fact, it's rarely been a major factor in adopting this new technique. More often, recorded information control is applied to downgrade unusual or hard-to-get labor skills. For example, a company that installed a punched-tape-controlled battery sealer did so when it could no longer hire the highly-skilled craftsmen who formerly handled the sealing operation. The company replaced the highly-skilled, difficult-to-obtain workers with a less highly trained machine operator.

In automatic testing operations, electronic companies have been able to use production workers with relatively low-grade skills to operate punched-card or punched tape-controlled testers instead of top-flight electronics technicians.

Bath-tub manufacturers have been trying out a variety of magnetic-tape-controlled devices to direct the spraying of frit (the ceramic coating) on red-hot cast-iron tub frames. The companies had used highly skilled artisans who did their spraying in asbestos suits to protect them from burns. But that made the job impossible to do in summertime. Recorded information control will make production a year-round possibility.

2. Boost capacity

Increased capacity of the control system is the major reason for magnetic-tape control of continuous contouring machine tools. Some contours on aircraft wings, for example, are so complex that cutting requires close control of three dimensions for long hours, up to 8 hrs for some skin milling. It's not possible to get an operator capable of taking such a physical beating. Magnetic tape has been able to do the job easily.

In automatic test equipment, capacity is also an important

ONLY KIN TEL DIGITAL VOLTMETERS GIVE YOU ALL THESE ADVANTAGES...

1. SINGLE-PLANE READOUT: KIN TEL digital voltmeters employ a simple projection system to present numbers on a readable single plane...no superimposed outlines of "off" digits...reduced possibility of error. Standard lamps give 7000 to 8000 hours of life, compared with 100 to 200 hours for ordinary readouts.

2. COMPLETE LINE OF ACCESSORIES—SPECIAL SYSTEMS: Versatile "digita' building blocks" permit measurement of AC, ohms, ratios of AC and DC, automatic scanning of multiple inputs. Preamplifiers increase digital voltmeter sensitivity to 1 microvolt DC, 10 microvolts AC. Buffers permit driving typewriters, tape punches and printers. KIN TEL's Special Products Department can design and manufacture digital instruments to meet your special requirements . . . complete digital systems for data logging, missile checkout and automatic production line testing.

3. ADVANCED CIRCUIT DESIGN: Transistors employed where they contribute to performance and reliability...relay drive coils energized with DC as in telephone type service to provide long, trouble-free operation...automatic, continuous standard cell calibration. No electronic circuitry in readout allows easy remote mounting. Sensitivity control permits stable reading of noisy signals.

4. MANUFACTURING EXPERIENCE: KIN TEL has manufactured over 10,000 "standard cell accuracy" DC instruments on a true production line basis. Only by this method, by years of repeated manufacturing experience, by an over-all awareness of the accuracies and tolerances involved, is it possible to guarantee consistent accuracy and reliability...to assure real value for every dollar you invest.

5. NATIONWIDE APPLICATION ENGINEERING FACILITIES: KIN TEL has engineering representatives in every major city. An experienced staff of over 200 field engineers is always immediately available to help solve your application problems, provide technical data, or prepare a detailed proposal. Factory level service is available in all areas.

+·7895

6. DESIDERATE SPECIFICATIONS (MODEL 401 DC DIGITAL VOLTMETER):



Display...Four (4) digit with automatic polarity indication and decimal placement. Total display area 2" high x 7½" long, internally illuminated. Individual digits 1⅛" high.

Automatic Ranges...0.0001 to 999.9 volts covered in four ranges. Sensitivity control provides least digit sensitivities of .1, 1, and 10 mv.

Accuracy...0.01% ±1 digit.

Counting Rate...30 counts per second, providing average balance (reading) time of 1 second, maximum balance time of 3 seconds.

Reference Voltage...Chopper-stabilized supply, referenced to an unsaturated mercury-cadmium standard cell.

Input Impedance...10 megohms, all ranges.

Output...Visual display, plus print control. Automatic print impulse when the meter assumes balance. No accessories required to drive parallel input printers.

Input...115 volt, 60 cycle, single phase, approximately 75VA.

Dimensions...Control unit, 5¼" high x 19" wide x 16" deep. Readout display, 3½" high x 19" wide x 9" deep.

Weight...Approximately 40 lb.

Price...$2,100

Write today for descriptive literature or demonstration. 5725 Kearney Villa Road San Diego 11, California

KINTEL

A Division of Cohu Electronics Inc.

factor. As electronics in computers and control systems has become more complex, more and more testing has been required. In a missile test system with 2,500 terminals, engineers estimated that 5 million circuit combinations had to be checked to insure against insulation breakdown. That's an impossible task for a man; but no problem for recorded information. And, there's much less chance for a mistake. (Even if the man is practically perfect and makes only one error in a million, that's still five shorts in the system.)

3. Increase output

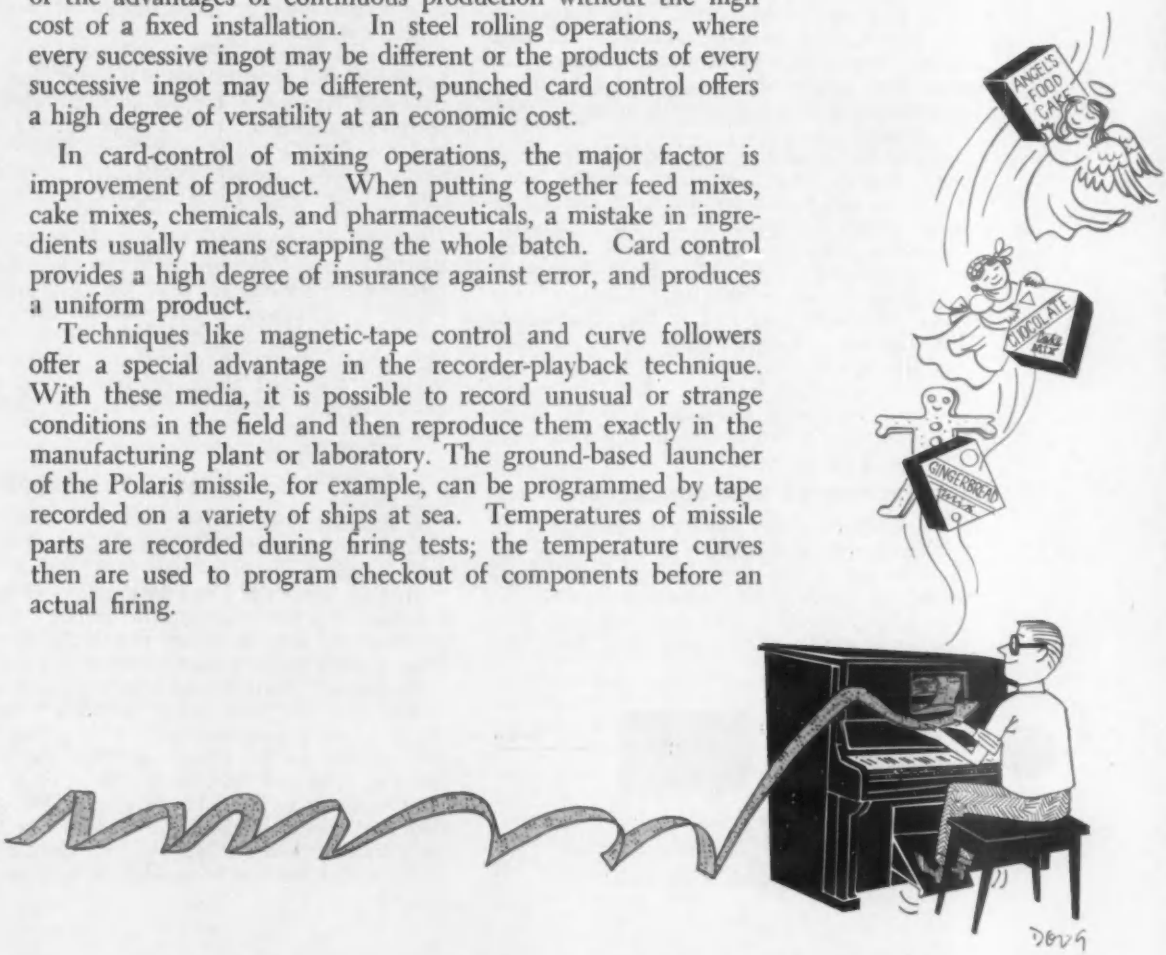
Steel mill companies have been applying punched card control to rolling mills to increase output. There's been significant improvement in blooming mills and reversing roughing mills. That's also the reason behind the activity in point-to-point positioning devices for welding tables, machine tools such as riveters, drill presses, boring mills, and punch presses. The control quickly and scientifically positions the tool, slashing hours from production jobs such as riveting an airplane wing.

4. Versatility

The tremendous production volume over a long period of time that's required to pay for a special-purpose machine like a complex transfer machine limits its use in most industries. But devices such as tape-controlled mechanical arms offer some of the advantages of continuous production without the high cost of a fixed installation. In steel rolling operations, where every successive ingot may be different or the products of every successive ingot may be different, punched card control offers a high degree of versatility at an economic cost.

In card-control of mixing operations, the major factor is improvement of product. When putting together feed mixes, cake mixes, chemicals, and pharmaceuticals, a mistake in ingredients usually means scrapping the whole batch. Card control provides a high degree of insurance against error, and produces a uniform product.

Techniques like magnetic-tape control and curve followers offer a special advantage in the recorder-playback technique. With these media, it is possible to record unusual or strange conditions in the field and then reproduce them exactly in the manufacturing plant or laboratory. The ground-based launcher of the Polaris missile, for example, can be programmed by tape recorded on a variety of ships at sea. Temperatures of missile parts are recorded during firing tests; the temperature curves then are used to program checkout of components before an actual firing.



Program Controllers Set the Pulsebeat of Industry

JOHN D. COONEY, Control Engineering

Somewhere in every control system is an element through which commands are introduced. This element establishes the cycle of operations (the routine, the program) that the system is to follow or, if the system regulates, sets its operating range. The command element may be as simple as the two- or three-position switch with which an operator sets the desired level of a liquid-level control system. However, the trend of today's control systems is to routines with a multiplicity of functions or operations that occur over longer periods of time. Hence, in an increasing number of cases, the command sources are not just simple components, but may themselves qualify as machines or subsystems. The equipments are distinguished by their flexibility and large capacity for storage of command routines, and range from synchronous-motor-driven cycle timers to magnetic tape transports with associated readout circuitry.

To tie this trend to the classical control-system block diagram (input, amplifier, actuator, etc.), it may be said that today the input end has assumed greater importance in relation to the overall system. In fact, the input arrow itself must be expanded into a distinctive block diagram to adequately encompass the new "hardware" and design techniques pertinent to the command or input function. "Program controller" is the name now gaining wide usage to describe the equipment associated with this function. And, the rapidly increasing technology associated with the design and application of this equipment is classed under the term "program control".

DISTRIBUTED VS. UNIT CONCEPTS

The control engineer may lay out the control for a complex cycle of operations in a process or machine in one of two ways. He may elect to distribute the command information among a number of program controllers, with each unit controlling a particular section of the processing or fabricating cycle. One example of this approach is a batch process, wherein a chemical solution is aerated for a period of time under control of a cycle timer; then heated along a specified time-temperature curve under the regulation of a pneumatic recorder-controller; and finally vacuum-aged under the regulation of another recorder-controller. A second common example of this approach is a transfer machine whose cycle of operation may include hundreds of steps, each controlled by individual limit switches and relays. Because the control responsibilities are divided among many elements and because the elements are physically distributed among the sections of the controlled apparatus, such systems may be called *distributed program control systems*.

The second broad subdivision comes under the heading of *unit program control systems*. Here the command intelligence for the complete cycle of operations is concentrated in a single program controller, such as a master cycle timer. This broad group includes recorded-information controllers, such as punched-card and magnetic tape equipments.

A program controller can be applied in both open-loop and closed-loop systems. When displayed as part of the block diagram of a closed-loop system, Figure 1, it appears as the reference command (arrow). Actually, a unit program controller is itself a subsystem with many parts. The simple reference command arrow expands into a new block diagram, Figure 2, that has six distinct functions:

1. Data computation
2. Encoding
3. Storage
4. Readout
5. Process computation
6. Output

To understand the broad implications of these functions, it is best to begin with "storage", which relates to the medium chosen to contain the program. Storage includes such elements as punched cards, magnetic tape, and charts inscribed with conductive inks. The prior block, "encoding", covers the preparation equipment used in recording the program data on the chosen medium. The term encoding is applied here because it is almost always necessary to translate the program information, as it appears originally on a process sheet or parts drawing, into the language or code peculiar to the storage medium being used. As an example,

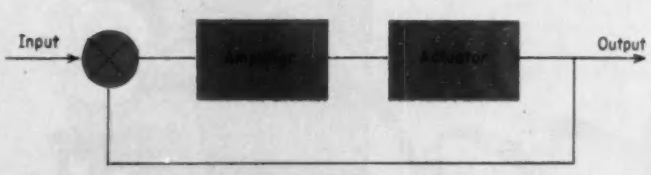


FIG. 1. Basic block diagram of closed-loop servo.

consider a drill press equipped with a two-coordinate table that is positioned automatically from a punched-tape program controller. The storage language of the 1-in. 8-channel punched paper tape medium may well be binary-coded decimal numbers, while the parts drawing will locate the holes to be punched in the workpiece by conventional decimal coordinates. The tape punch must then be arranged to accept decimal numbers at the keyboard and convert these into binary-coded hole arrays on the tape.

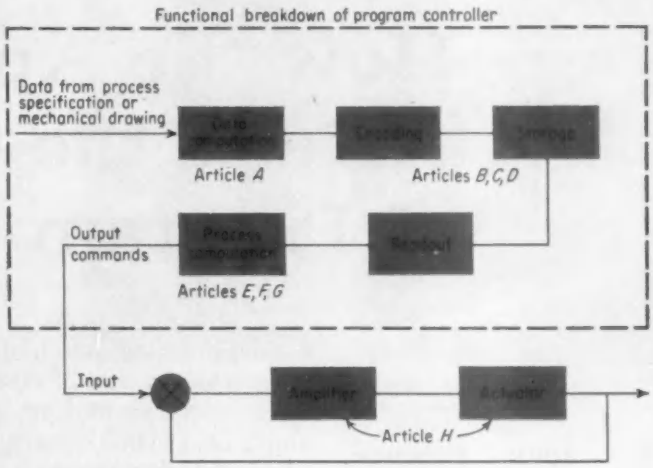
In some cases, the conversion of drawing or process-sheet data into a stored program goes beyond the encoding function. Certain computations may be required before the data can be given to the encoder. This is the function of the first block, labeled "data computation". The drawing of a part into which a channel is to be milled, for example, will give the location and dimensions of the edges of that channel. These edges define the path that the edge of the milling cutter is to follow. However, in milling-machine work, the control of all tool movements is referred to the center of the cutter, not its edge. Hence, before a program describing the making of this channel cut can be encoded on tape, the drawing must be redimensioned to show the path of the tool center, or in other words to show how much the cutter center must be offset from the channel edge to produce that edge. Such redimensioning may in some cases be done manually, or may require the use of a large general-purpose data processing machine when complex contouring is involved.

The "readout" block represents the equipment, such as tape transports or card-handling machines, needed to retrieve information in storage. The data readout is usually in the form of electrical signals which are patterned directly after the code or language of the storage medium. These signals are fed to the "process computation" equipment, where they are converted into command signals that are usable by the power servos or control elements in the process or machine. The computation block takes many different forms and may be of any degree of complexity. Typical circuits range from comparatively simple decoding matrices and digital to analog converters, to complex pulse generators and linear or parabolic interpolators.

A PROGRAM FOR PROGRAM CONTROL

The undisputable and growing importance of program control, plus the recent rapid advances in the techniques and equipment associated with it, prompted CONTROL ENGINEERING editors to devote this entire issue to the subject. Figure 2, in addition to serving as a vehicle for explaining the functions within program controllers, also displays the program of this issue. Each basic article is fitted into its appropriate block on the diagram.

The first four articles are devoted to *Equipment for Program Control*. Program controllers (ranging from telephone dials and selector switches to curve followers and photoelectric tape readers) demand study by the control engineer if he is to put them to correct use. Dutcher's article sums up extensive



How to Key the Block Diagram to Article Content of This Issue

A—How the Application Affects the Choice of Program Controller
B—New Developments in Program Control
C—Selecting Punched Tape or Punched Card Equipment for Program Control
D—Selecting a Magnetic Tape System for Program Control
E—Putting Logic to Work in Designing Distributed Program Control Systems
F—Converting Pulse and Coded Data Into Usable Output Signals
G—Interpolation—A Link Between Programmed Points and Smooth Curves
H—Designing Drive Systems for Compatibility with Program Controllers

FIG. 2. Diagram showing the relation of program-control functions to the overall control system.

experience with many forms of program control and makes recommendations for using each type to best advantage. Kompass describes some novel, ingenious program controllers (character readers, curve followers, etc.) that are assuming importance in this field. Young covers punched-card and punched-tape equipment, evaluating various types on the basis of ease of encoding, storage capacity, and readout facilities. Halfhill and Wildanger do the same for a second major group of program controllers—magnetic tape apparatus.

The four succeeding articles cover *Design of Programmed Systems*. Mathias explains the logical techniques (Boolean algebra, truth tables, Veitch charts, Karnaugh maps) adopted only recently by control engineers, in both process and heavy machinery industries, who choose the distributed-programmer approach. Mergler and Johnson devote their efforts to the "process computation block. Manipulation of codes and the circuitry for analog to digital conversion are concentrated on by Mergler; Johnson reviews the mathematics of interpolation and the schemes for mechanizing this mathematics. Winget discusses how the link between program controller and the controlled equipment should be designed to guarantee good overall performance.

Lastly, a group of engineers in the material process, heavy-machinery, and aircraft and missile fields describe actual applications of program control. The range and variety of these applications do much to justify this special issue—and should stimulate every control engineer to assess the potential of program control in his industry.

How the Application Affects the Choice of Program Controller

JOHN L. DUTCHER
General Electric Co.

Engineers in the industrial machinery field undoubtedly have logged the greatest amount of experience with program control systems. And this is experience in depth—covering the full range of techniques from simple limit-switch circuitry to the newest forms of numerical controls. The author draws on such experience to evaluate the various program approaches for specific applications—always on the basis of the cost of performance vs. the need for it. This type of information will become increasingly important to other control engineers, especially as the newer control techniques gain a foothold in their industries.

When deciding on the type of program control needed for a given application, the control engineer has one major objective: to select the system that will produce adequate performance at the least overall cost. This seems to be an obvious criterion, but it is often made secondary to the details of the hardware involved, to initial cost excluding operating costs, or to extreme accuracy capabilities—even when such accuracy may add nothing to the value of the end-product.

There is no one formula which can be applied to the selection of programming systems; their end uses are too diversified. An accuracy improvement of 0.001 in. is of real value for machines used in the aircraft industry, because a tighter tolerance on all machined parts in an airplane means a reduction in weight of possibly several hundred pounds, and thus increased payload. But the same accuracy improvement in locating the holes in the end plates of a boiler probably would be of little worth. Again, a high degree of flexibility in a program controller is attractive to the small job shop, or in development or prototype manufacturing. However, it may simply be a nuisance to the shop which makes duplicate parts in lots of thousands. Thus, consideration of the end-use also enters heavily into program controller selection. A score card listing the advantages of one type of program controller vs. those of another in one specific field of application might show completely different results than one for the same two controllers in a different field.

The distributed program-control system is the most frequent choice of the control engineer. This approach is characteristic of the great majority of automatic controls in such diverse areas as household appliances, the process industries, and metalworking. The methods and hardware are proven and performance is adequate for most applications. And, for machine and processes designed exclusively for one particular product, there is little question about the economies that result from the use of distributed program control. The transfer machine, Figure 1, is a case in point. Many individual machines are also made automatic through the use of the same programming techniques. Cams and limit switches plus relay circuitry allow them to produce parts with a fairly high degree of automation.

The inherent disadvantages of distributed program systems are inflexibility and limited practical memory capacity. For this reason, the alert control engineer often has to look to other types of program control.

The flexibility of distributed program systems can be considerably advanced by concentrating some of the control functions in units that are adjustable to at least a limited degree. Cycle timers, recorder-controllers, and limit-switch mounts that can be set to various positions are examples of the type of hardware that permit changes in operating cycles. Another approach is the use of drum-type controllers, of which the Bullard Man-Au-Trol, Figure 2, is a classic example. Designed especially for vertical turret lathes, this controller uses a memory or function drum consisting of a steel cylinder with rows of holes. Pins screwed into these holes in any desired pattern are used to actuate electric switches as the drum rotates. The drum has 49 index positions for 49 preselected combinations of machine functions (spindle speed, traverse, feed, turret index, etc.) for the machining cycle.

In addition to the memory drum, there are two rotary detector drums driven directly from the horizontal and vertical feed screws that operate the head. Each drum has 49 adjustable rotary discs for controlling the length of head travel along one axis. Each disc has a switch-tripping dog which stops the feed when the required position is reached.

UNIT PROGRAM CONTROLLERS

The measures for increased flexibility just described clearly indicate the shift toward the unit concept of

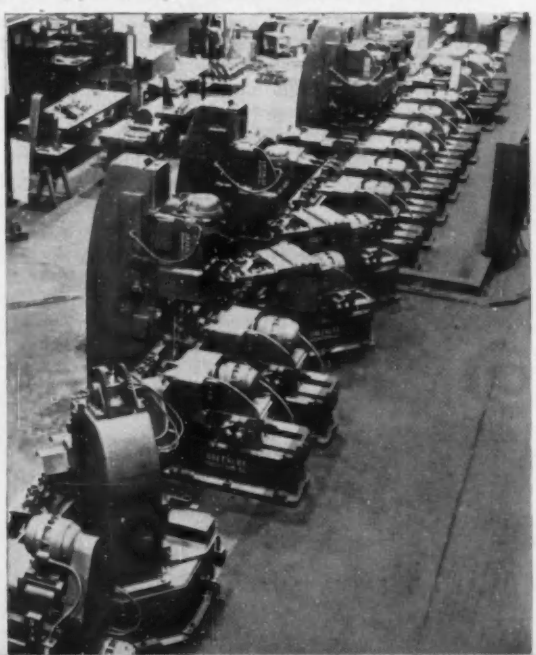
program control, whereby most or all of the control information is assigned to a single storage element. To change a program of operations, it is necessary only to replace or adjust this element.

In the machine-tool field, one of the major examples of the unit program controller concept is tracer-type equipment in which the program is stored in the form of a template or model. A tracer head or stylus contacts the surface of the template and controls the machine feeds so that the tool holder will follow the desired path. Simple one-dimension tracers are used extensively on lathes, vertical boring mills, and some special aircraft milling machines, Figure 4. At the other extreme are three-axis units used to machine complex three-dimensional shapes such as dies.

The newest and probably most promising unit program controllers are those of the numerical type, in which the program is stored on punched cards, punched tape or magnetic tape. According to their function, numerical control systems are classed under two main headings: positioning (or sequencing) controls and continuous-path controls. Under numerical positioning control, a machine is positioned to a series of discrete points for drilling, punching, welding, boring, etc., without particular regard to the path followed between those points. The coordinates of the desired points are punched in cards or tape, along with other coded letters or numbers that determine the sequencing of additional machine functions.

These systems perform many of the same functions as do the distributed program control or the mechanical drum, but have a number of added advantages. First, they are extremely flexible and can be applied to almost any type of machine or process that requires automatic positioning or sequencing. One such system has already been applied to more than 10 basically different types of machine functions, including punch-press, precision boring, steel-mill screw-down control, as well as drilling (Figure 3) and others more obvious.

FIG. 1—Transfer machine for machining refrigerator compressor bodies. These machines have a built-in program consisting of relay circuitry, limit switches, positive stops, and other mechanical devices.



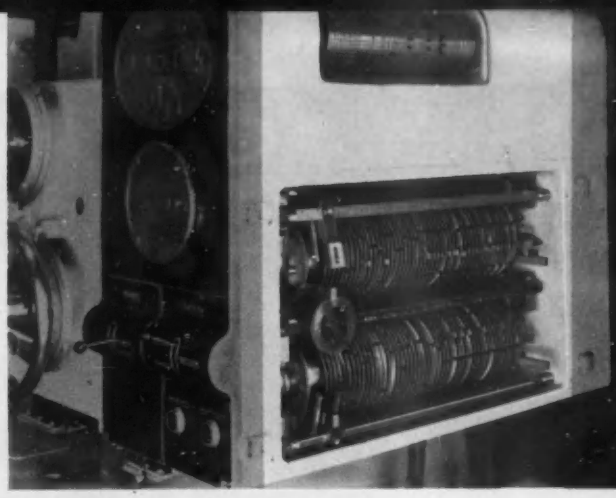


FIG. 2—Bullard Man-Au-Trol program controller applied to a vertical turret lathe. Covers are removed to show function drum at top and two detector drums.

The feature of these machines contributing most to savings in operating costs is their ability to quickly change from the production of one part to another. Beyond changing tools and possibly part-holding fixtures, all that is required is to insert a new section of tape or a stack of punched cards. Setup time is therefore almost negligible. They also permit much more rapid positioning than is attainable by a human operator and provide almost any accuracy within machine capabilities.

The acceptance of numerical positioning control is presently high because it is simple to understand, comparatively inexpensive, applicable over a broad field, and results in appreciable reductions in production costs. The primary areas for numerical control are positioning tables, drills, boring machines, punch presses, welders, and jig borers, but it is being considered for many other applications where sequencing is required. Steel-rolling mills and printing presses are examples outside the machine-tool industry.

Positioning accuracies vary from plus or minus 0.005 in. on punch presses or welders to as high as plus or minus 0.0001 in. on jig borers. Positioning speeds of 50 or 100 in. per min. are common and speeds up to 600 in. per min. are feasible with some sacrifice in accuracy. A good two-axis system complete with paper-tape reader and power servos can be had for about $10,000. This means that a machine complete with a numerical positioning system may cost roughly $15,000 more than a comparable standard machine.

There are various types of numerical positioning systems presently on the market. Choosing among them on the basis of hardware and operating principles alone is an enormous task. The systems are digital, analog, or a combination; electronic or non-electronic; and use almost every conceivable form of data-input medium, and essentially all types of power-output devices.

One important recommendation that can be made is that the system use standard types of input tape or cards, for which efficient punching equipment is readily available. IBM or Remington-Rand cards or Flexowriter tape are satisfactory; data can be recorded on these media by simply typing it in English on a standard keyboard typewriter. In contrast are systems

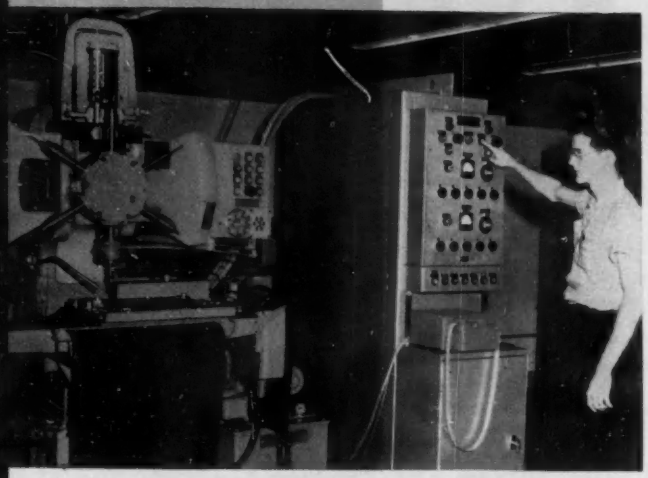


FIG. 3—Drilling machine equipped with numerical positioning control. Punched tape reader is visible at the right.

that require the data to be punched, one hole at a time, after reference to a code table.

It is important for the control engineer to ascertain that the system being considered provides all of the individual functions required. Beyond this, selection must be based largely upon whatever reliability records are available for the control system. At this stage in the technology, few people are competent to judge the capabilities of a numerical control system by simply studying circuits and hardware. If the system has previously performed successfully on the general type of application being considered, it is reasonable to assume that essentially similar results can be expected again.

Numerical positioning controllers are somewhat unique among the various relatively complex machine control systems in that the design of a basic system that will read numerical data and operate power servos is not particularly complicated. Many of these controllers have been built on a small, more or less do-it-yourself basis. However, this approach is not without some pitfalls. First, there is a tendency to start building before all the associated factors, such as the means of data preparation, have been considered. Too little attention is given to the selection or design of the output power actuator and the integration of it into the machine design, a factor that is of extreme importance to the success of any system.

Also, there is a big step from a successful laboratory breadboard equipment to one that is designed and packaged to operate reliably for many years in a production shop. Some maintenance will certainly be necessary and this requires good construction techniques, good circuit diagrams and instruction manuals, plus the availability of experienced service personnel.

CONTINUOUS PROGRAM CONTROLLERS

The second form of numerical control system is the continuous-path or contouring type, which controls tool path from a program punched in cards or tape or recorded on magnetic tape. The use of numerical contouring equipment is much more complicated than any of the other program controllers because of the fairly complex data preparation needed. A planner must first determine and list the sequence of cuts required, providing enough data to describe the shape of the part. This data is then generally fed to a digital computer, which computes appreciably more data describing the actual tool path. Finally, this computed data must be converted, by other equipment, to the form required by the machine control.

Because of this computation requirement and the relatively high first cost, numerical continuous path control is being accepted less rapidly than some other new programming systems. However, it is making headway because of the major savings in machining costs and the greater accuracy that it makes possible. Numerical contouring is used largely on milling machines (Figure 5) for the type of work that would previously have been done with template tracers. With numerical contouring, overall accuracies of plus or minus 0.001 or 0.002 in. are practical. Feed speeds up to 100 in. per min. are used in milling aluminum.

TRACER VS. NUMERICAL CONTROL

In many applications requiring continous-path control, the control engineer may be called upon to choose between tracer and numerical systems. Sufficient operating experience with both types is now available to make possible an intelligent comparison of the two approaches.

Template tracer equipments are available in an assortment of types and sizes, from simple one-dimension units priced at $2,000 or less to highly accurate three-dimension die-sinking-type units in the $20,000 range. In contrast, the program controller and power servos for a three-axis numerical contouring system may be priced anywhere between $30,000 and $70,000. This cost does not include all of the equipment involved, since to use such a system it is necessary to have access to a digital computer and to some additional data-processing equipment. But despite these cost factors, there are many types of contour machining that can be done not only more accurately, but also more economically with numerically controlled contour milling or turning machines.

To consider the relative merits of tracer vs. numerical control, it is best to consider turning and milling applications separately. Many template tracers have been used on lathes for work such as shaft turning. These tracers are the simple, inexpensive types, and they will have little competition from numerical contouring systems (though they are losing some ground to the less-expensive numerical positioning systems).

A tracer controlled machine can produce parts that are no more accurate than the template as mounted on the machine. Good templates are generally accurate to plus or minus 0.002 in. and some cases possibly plus or minus 0.001 in. This is not good enough for a new class of parts having irregular contours that must be turned to accuracies of plus or minus 0.0001 or 0.0002 in. Whether or not these accuracies are practical with any combination of machine, tooling, and control system, only time will tell. However, it is required that these parts be as accurate as is possible with any reasonable amount of effort. This is one area where numerical contouring systems will have to be used; they eliminate many of the major errors of template tracers and do not necessarily add any appreciable new ones.

But numerical contouring with milling machines has a much broader base of potential application than this. It is already in use machining all types of aircraft structural parts, machining jet engine and turbine blades, producing various types of cams and templates, and sinking dies.

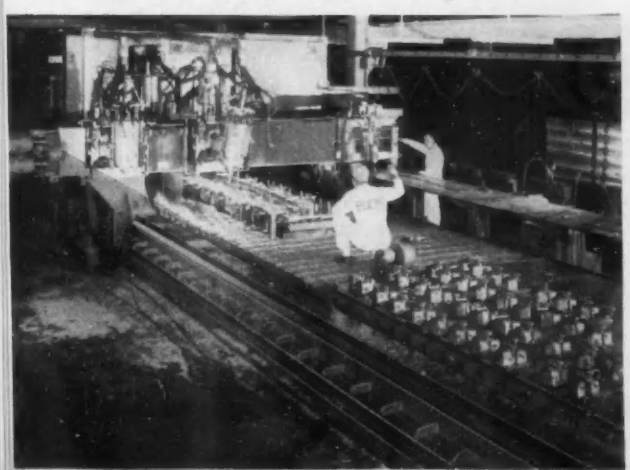
A study by representatives of the aircraft industry has outlined three major areas in which advantages will be realized by using numerical contouring machines. The first of these is improved machining accuracy—the template, template mounting, and tracer head mounting, which are major sources or error, are eliminated. The numerical equipment checks itself to a large extent and automatically stops if it does make an error. Every reasonable effort is made to insure this stopping before serious damage to the part results. There are no errors of any consequence that are introduced by the numerical data processing that cannot be found and corrected at least by the time the first part is made. Thus, in the average case, it is reasonable to expect 0.005 in. accuracy in production milling with a tracer system and possibly 0.002 in. accuracy with numerical contouring.

Another benefit is lower production costs, principally from better machine utilization. Machining time is reduced by 50 to 70 percent because setup is simplified and the machine operates at optimum speeds. Template manufacture and storage costs are also eliminated. Work-holding fixtures thus are less complex and less expensive. The machines are smaller and more compact because space for mounting templates is not needed. Less floor space is required and, in some cases, a less-expensive machine will be satisfactory. Cost of scrap parts and rework is appreciably reduced.

Moreover, numerical control reduces the drawing-to-part time. Preparation of the program consists of planning, compiling relatively simple part data, and then the operation of automatic computing and data converting equipment. This replaces the planning and manufacture of precise templates or models used with tracer systems. In turbine or jet-engine-blade manufacture the production of the model blade (template) for a tracer machine generally requires weeks or even several months. With a numerical system this lead time can be reduced to as little as one day.

The control engineer must be aware that numerical contouring systems present some serious problems to the user at first. One of these is the need for reorganization of parts of the manufacturing operation. In the past it has been possible to operate efficiently with engineering, production, planning, tool design, cutter design, and production machining set up independently. With numerical control the intelligence contributed by these various skills must be brought together and synthesized in a series of electronic commands recorded on the input tape. This requires close cooperation among these various skills, changes in operating procedures, and probably changes in manufacturing organization at least in the larger facilities.

FIG. 4—Tracer controlled spar and skin milling machine installed in an aircraft plant. The template mounting table and tracer head are in front of man at right.



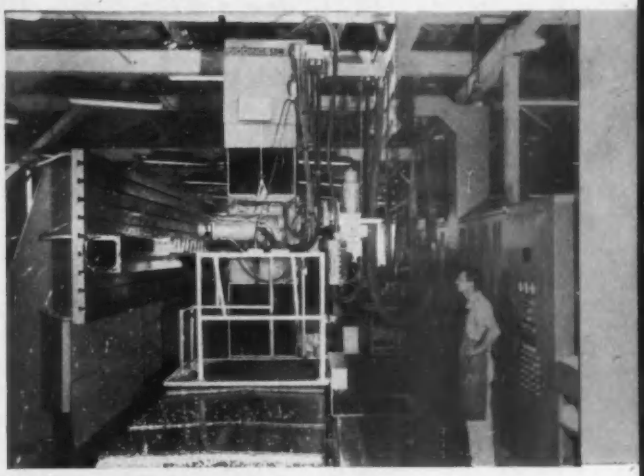


FIG. 5—A profile milling machine equipped with numerical contouring (continuous path) control. Program recorded on magnetic tape automatically controls machining of aircraft parts.

In addition to higher first cost of the numerical contouring control system as compared with a tracer system, there is in many cases the higher cost of the machine tool itself. Since numerical control provides the potential for appreciably more accurate machining at higher speeds, numerically controlled machines are being designed with accuracies and rigidity far exceeding that existing in most tracer-controlled machines.

Numerical contouring equipment is more complex than anything previously used with machine tools. Thus, higher maintenance skills are required. However, initial experience indicates that unscheduled downtime will be no greater than that experienced with other types of reasonably complex control systems.

The factors to be considered in selecting one specific numerical contouring system are much the same as those mentioned previously for numerical positioning systems. The steps in preparing the machine input data, however, must be investigated to a greater degree, for data preparation is a major part of a numerical contouring system. Among available systems, the equipment concerned with computing and numerical-data conversion may be divorced completely from the equipment connected to and installed with each machine tool, or a portion of this equipment may be incorporated in each machine control. On the one hand, data need be handled only once for each type of part, and one set of data-processing equipment is enough to serve an appreciable number of machines. On the other, there is a lower first cost for the first one or two machines since less separate data-processing equipment is required. However, for larger numbers of machines, the cost becomes greater because of the resulting duplication of equipment.

New Developments in Program Controllers

E. J. KOMPASS
Control Engineering

Certain trends are discernible in the designs of new programming devices that have appeared recently, flexibility of program content being one of the more important. Many relatively new devices are described in this article (some of which you may not have thought of as programmers), including card and tape readers with special characteristics, and machines that can read the ordinary printed page directly. The idea is to suggest the kinds of devices that can be useful, and the directions that programmer designs may take.

A program is a set of instructions that defines a desired sequence of conditions for a process or function and the operations required between these conditions. Programs were originally written to be read by an operator who would then perform the operations required in the proper order. Later, machines were developed that could read specially prepared programs and direct a process automatically through the sequence of operations required. These automatic program readers or programmers are still developing.

Several trends are noticeable. The most important characteristic required for new programmers seems to be flexibility or ease of changing the program. Another is greater program capacity and a third the ability to provide a permanent record of the program used. Several new punched card and punched tape reader designs featuring permanent-record facilities are described in this article.

Because a program defines a sequence of events, a programmer is easily designed as a digital device. But as the conditions defined by a program become closer together in time or in space, or as the times between program steps become short compared to the time lags of inertias of the process, the programmer might better generate a continuous path or analog signal. Various analog function generators and curve followers are described here that could be very useful as programming devices.

The latest developments indicate that in the future machines may be available to read handwritten or typewritten programmed directions directly. Special codes and preparation devices then would no longer be needed. The original description of the program could serve as a permanent record. Certain automatic character reading and pattern recognition machines are therefore discussed briefly at the end of this article.

SPECIAL TAPE- AND CARD READERS

Typical of the trend to high-capacity, permanent record programmers is a punched-tape reader recently announced by Industrial Timer Corp. This unit permits simultaneous control of up to 85 separate circuits. A paper and Mylar laminated tape, 85 channels wide, can be read at speeds up to 12 steps per sec. There are 64 possible steps for each foot of tape length, and the tape can be fed from a roll, or connected end-to-end as a loop if repetition of the program is desired (Figure 1). The number of program steps is limited, as with other tape readers, only by the length of the tape used.

The reading brushes are rated ½ amp for direct circuit actuation, but auxiliary memory load relays are available with contacts rated at 10 amp. The load relays are connected to be closed by a pulse transmitted through a hole punched in the tape, and to remain energized until released by a pulse from the next hole in the same channel. Load relays are the sealed, plug-in type, with pilot lights that indicate when each relay is energized.

The programmer can be self-stepping or stepped in accordance with an external signal. Lights are provided which indicate the active program step. An optional dual timer permits time-base operation. A prototype of an automatic tape punch

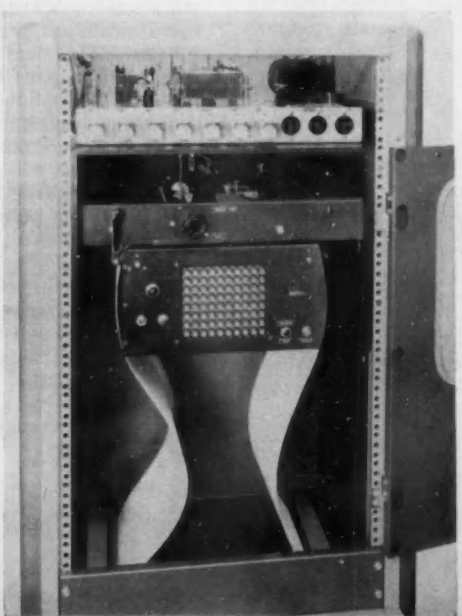


FIG. 1. Eighty-five-channel tape reader by Industrial Timer Corp. Hole in any channel closes load relay until next hole in the same channel releases it.

for this programmer is now operating. The special tape punch presently available must be operated manually.

A completely different approach to simultaneous control of independent switching channels has been taken by Vitro Laboratories. The Vitro programmer, not commercially available, was designed to be carried in a torpedo or missile, and also uses a roll of paper tape for a permanent record of the program. But the program data is painted on, rather than punched into, the tape. The programmer tape is chart paper imprinted with 10 parallel channels running longitudinally (Figure 2). Time in seconds is marked along the edge of the tape at spacings that depend on the chart speed used. A speed changer permits speed to be varied from ⅛ ips to 6 ips.

The time at which any particular channel is to be energized and de-energized is programmed by painting that interval of the channel with an acetate-vehicle silver conductive ink. The various on-off signals shown in Figure 2 are typical. The tape, with its recorded program of conductive intervals, is then drawn over a commutator by the tape transport. Imbedded in the commutator, a fixed rod-shaped insulator at right angles to the tape, are 11 contacts—one beneath each tape channel, all 10 adjacent to one another in a straight line across the tape; the 11th is a common segment running all the way across, closely spaced to the other 10.

Each channel segment of the commutator can be connected to a relay, which will close when a conductive interval in its channel shorts its particular segment to the common side of the relay power supply. The relay will remain closed as long as its channel is conductive, a situation that depends, as noted before, on the length of the channel painted and on the chart speed.

The programmer is small and simple (Figure 3); preparation of its tape demands no special tools. The tapes are permanent records that can be rerun many times with good reliability.

Block-at-a-time tape readers

Two other tape readers of special interest have appeared recently. Both read standard 1-in. punched tapes, a block of holes at a time, indexing the tape in frames of several lines. In this way, a large number of bits of data can be read simultaneously (a feature of punched cards), and handled easily (a feature of paper or Mylar tapes). The so-called Tape-Ard Reader of California Technical Industries was shown first; it can read 10 rows of a standard eight-channel tape simultaneously, by contacts rated at 100 ma. The Tape-Ard Reader will read better than 15 80-hole frames per sec, but a maximum of six frames per sec is recommended for continuous operation.

The second punched-tape block reader was just announced in June by Wang Laboratories. It can read five- or eight-channel tape, 12, 16, or 20 lines at a time, at speeds up to 10 frames per sec. Visual indication of the block pattern is available on both readers for verification of newly punched tapes.

Ideas in card programming

Another interesting idea in multiple circuit switching is the punched-card-operated switch developed by Hickok Electrical Instrument Co. This unit uses a very stiff cardboard or plastic card to close self-cleaning con-

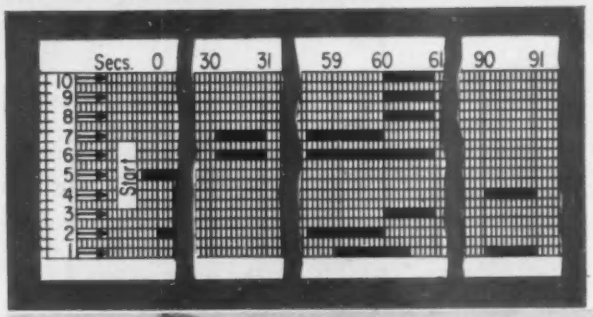
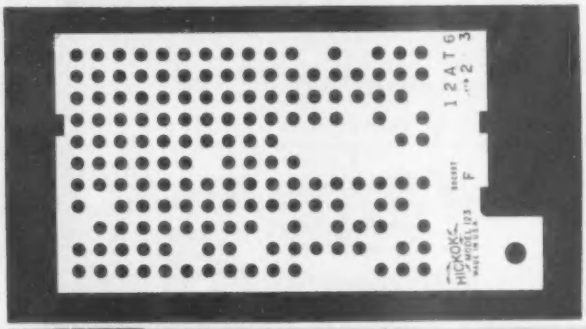




FIG. 2. Relays associated with each of the 10 channels on this paper tape are closed for duration of strips painted on tape with conductive ink.

FIG. 3. Programmer by Vitro Labs draws tape of Figure 2 over special commutator (see text).



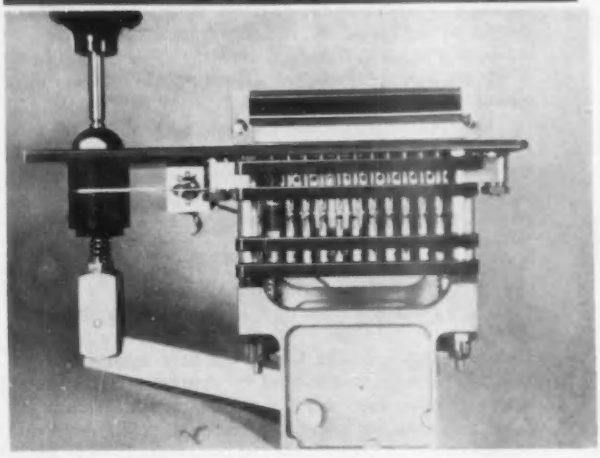
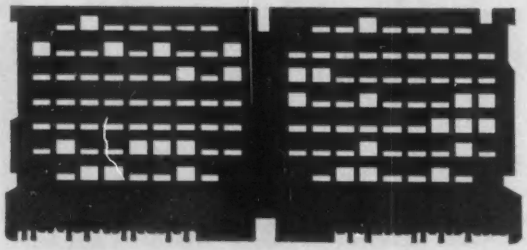
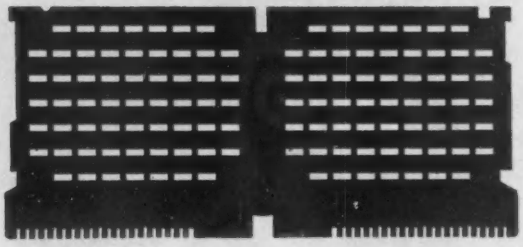


FIG. 4. Special card used in Hickok card reader (see Figure 5) closes switch contacts where no holes are present in card.

FIG. 5. Lever at left cocks spring-loaded contacts which are released by insertion of card.





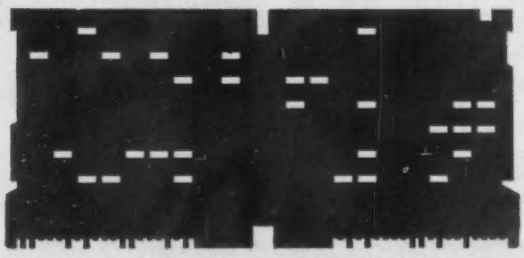


FIG. 6. Typical card used in Bell system translation equipment for long-distance dialing.

FIG. 7. Blank, uncoded card. Also, looking through stack with all cards in normal position.

FIG. 8. Looking through the end of the stack with single card (coded as in Figure 6) dropped by coding bars.

tacts rated at 10 amp each. The contact is not made through the holes in the card but by spring-loaded contacts that are closed by pressure against the card when no hole is present. A typical card is shown in Figure 4. This card would actuate the 22 contacts in the positions where no holes are present in the card matrix.

The mechanism of the Cardomatic switch is shown in Figure 5; it has 187 spring-loaded contacts which are cocked by depressing the lever at the left. Insertion of a card actuates a momentary solenoid trip device to release the spring-loaded cam when a card is properly positioned. Absent holes restrain the switch pins. The contacts will not close if the mechanism is actuated accidentally when a card is not in place.

An interesting feature of this unusual programmer is that the program can be varied manually by inserting a plastic plug from the top of the card reader through any desired hole in the card to depress a contact. An entire program can be set manually in a card with all holes punched by inserting plastic plugs to close the desired contacts.

The problem of high-capacity, flexible automatic program selection is neatly solved in a card translator developed by Bell Telephone Laboratories for routing toll calls originating from dial telephones. The translator uses cards like that shown in Figure 6, in which the enlarged holes represent coded routing information. An uncoded card is shown in Figure 7. In the translator, the cards stand vertically, resting on the coded tabs at the bottom. As many as 1,200 cards can be stacked in one translator so that the holes form horizontal tunnels or channels through the entire stack of cards. In the normal condition, all cards are supported by the long tabs at the ends. Looked at through the end of the stack, the hole pattern will resemble the uncoded card of Figure 7.

Thirty-eight code bars are arranged lengthwise below the stack, beneath each of the small tab positions on the cards. When a subscriber dials a toll number, the first three numbers, designating the office called, pull down corresponding code bars below the card. This removes all support under the card to be selected, which then drops a distance slightly greater than the height of an enlarged hole. All the other cards in the stack are still supported by at least one tab and are not dropped.

When the selected card drops, it blocks all channels through the stack except those in which it has enlarged holes. The pattern through the stack then looks like the code pattern in the particular card selected (Figure 8). This code pattern contains all the program information for routing the call to the office dialed. Modulated light supplied by mirrors and lenses at one end of the stack falls on an array of phototransistors at the opposite end.

These card translators have been routing long distance calls for several years. The phototransistors used represented the first large-scale application of transistors in the Bell system.

This description of the operation of the card translator has been extremely simplified to point out how the program on a single card is selected from a very large card file. A few translators in any telephone switching office can connect a caller to any other office in the United States or Canada.

ANALOG-OUTPUT PROGRAMMERS

Curve followers are special function generators that may be considered analog programmers. They are generally available as accessories for x-y recorders. The output of such curve followers may be made a function of time by driving one axis with a synchronous motor, or a function of some other variable (as for automatic compensation) by servoing one axis to that variable.

There are many ways to make a pickup follow a continuous curve. In one, a high-frequency current source is connected to the ends of the curve, which is drawn on a chart with conductive ink. The current is sensed by a pickup coil and converted to a dc servo signal in a phase-sensitive detector. A design of this kind is used by F. L. Moseley Co. in the curve follower attachment for its Autograf x-y recorders (Figure 9).

Another method is used by Electronic Associates in earlier models of its Variplotter. The ends of a resistance mandrel on the follower head are connected to positive and negative supplies so that a phantom ground or zero potential appears in the physical center of the mandrel. A soft drawn copper wire is laid care-

fully on the chart paper of the x-y recorder along the curve to be followed. It is held to the chart by transparent tape with adhesive on both sides, and connected to the input of the servo that drives the curve follower, which will then drive to keep the follower centered on the wire. Figure 10 is a photograph of this follower. The second axis again can be driven as a function of time or some other variable.

Another technique is to use a carbon film resistance plate in which the desired curve is scribed. The scribed line divides the plate into two areas, the edges of which are connected to positive and negative supplies or to opposite phases of an ac supply. A simple brush pickup connected to the input of a servo amplifier will then drive the pickup to the scribed line. This technique was described by T. Arima and B. Saito in the "Journal of the Society of Instrument Technology", Japan, Vol. 7, No. 8. The principle is illustrated in the diagram of Figure 11.

Note that in each of these systems the servo which positions the follower head also drives an auxiliary potentiometer to provide the output signal or program to be followed. One of the advantages of the curve follower is that the program can be prepared rather simply as an analog curve and need not be specified as a large number of points. Even a large number of points can require interpolation.

Other function generators

Other kinds of function generators can also direct the behavior of a process or process function. The Vernistat Function Generator made by Perkin-Elmer Corp. offers a simple and direct way of producing an ac voltage amplitude that is some desired nonlinear function of a shaft rotation. This function generator uses a modified interpolating Vernistat with 100 taps connected to a 31-pole, 100-position printed-circuit switch. Any of the 31 poles can be connected to any of the 100 taps. The potential of each pole can be adjusted to any fraction of the input voltage within ½ percent of total voltage. As shown in the photograph of Figure 12, the 31-pole switch is designed into a panel which gives a visual presentation of the output function. The presentation can be adjusted easily by moving the switch sliders. The x axis of the panel represents shaft rotation and the y axis output voltage. The Vernistat interpolates linearly between each adjacent pair of the 31 points.

Any of the diode function generators available for

FIG. 10. Early Electronic Associates curve follower used resistance contact pickup on copper wire placed over curve.

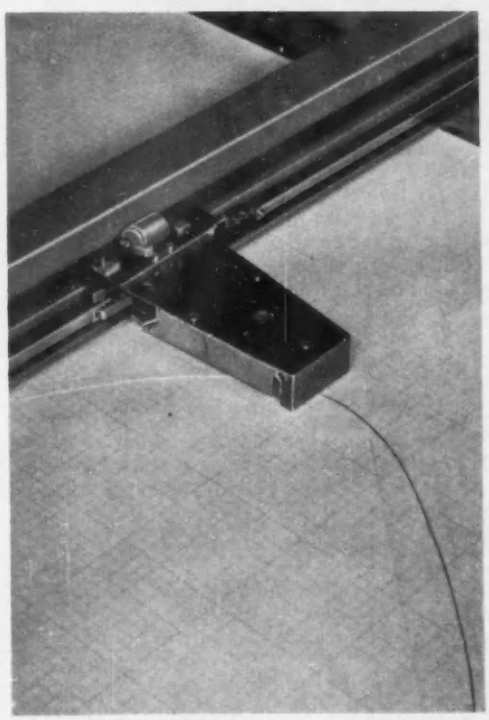




FIG. 9. Curve follower attachment for x-y recorder by F. L. Moseley uses inductive pickup to servo follower on inked line.

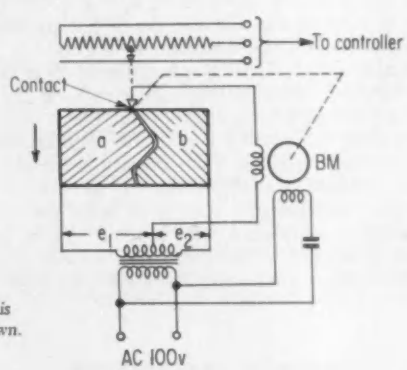


FIG. 11. Japanese curve follower scribes line on conductive surface, divides it into two areas, A and B. Contact position is then servoed to scribed line by system shown.

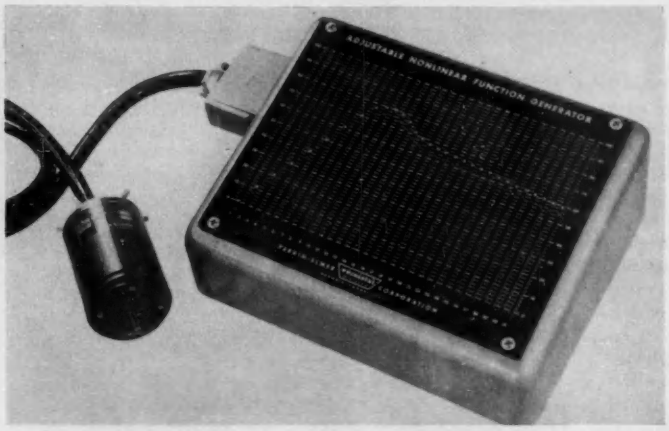


FIG. 12.
Function generator uses modified Vernistat to produce nonlinear ac voltage (y axis) as function of shaft rotation (x axis).

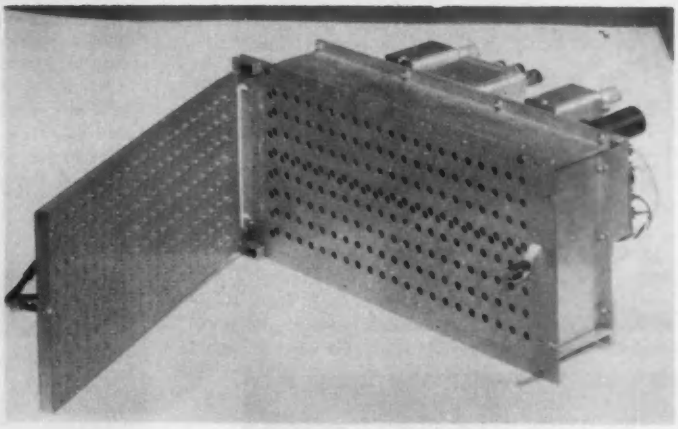


FIG. 13.
Diode function generator by Electrol, Inc., is set up automatically by punched card inserted in door at front.

analog computers become flexible programmers when the proper scanning signal is applied to the x axis. The output of the y axis would then represent the analog program signal. Electrol, Inc., has recently announced a card-programmed diode function generator which does away with the necessity of setting up many potentiometers. At the same time the card becomes a permanent record of the program. The programmer shown in Figure 13 is designed for rack mounting. In use, a prepunched card is passed behind the front door; as the door is closed spring-loaded plungers pass through the holes in the card to actuate sealed switches. The switches set up resistor networks in accordance with the desired function. The function may be composed of 20 linear segments with slope values from 0.01 to 10.16 volts per volt. Zero offset, slope, and scale factor for each segment are programmed on the card.

A very different approach to analog function generation is used in the Phosiac developed by the Steven Douglas Co. Phosiac (diagram in Figure 14) produces an analog output signal as a function of three independent variables. This system uses a cathode ray tube to scan a 1¼-in.-sq photographic plate. The position of the beam along the x and y axes of the plate are two of the independent variables. Film density is the third.

To eliminate variations due to photographic processing, a standard gray scale is included on each plate. A two-gun cathode-ray tube is used. While the input x and y voltages locate one beam an electronic servo positions the second beam along the gray scale until its effect on the photomultiplier is the same as the first beam's. The linear deflection voltage for this second beam is thus the z output. A single photomultiplier (block diagram) detects the two light spots projected through the data plate and the gray scale. Each spot is modulated at 5 kc but 180 deg out of phase. A comparator circuit drives the electronic servo to make the amplitude of the signals from both beams equal. The second photomultiplier is used in an intensity control loop to remove the effect of sensitivity variations across the face of the cathode-ray tube.

The data plate is prepared from data relating the three variables on a punched-tape-programmed master film maker, which produces a total of 300 scans.

CHARACTER READERS

Instructions for the desired behavior of some function usually involve special codes and coding equipment as well as special preparation equipment like tape punches or, as in the case last cited, an automatically programmed film maker. Quite a lot of investigation has been going on recently, however, into the possibility of developing machines for reading handwritten or printed matter directly. From the point of view of programming, it is easy to see that such devices could eliminate all special preparation equipment and permit anyone with a pencil or ordinary typewriter to prepare program information for direct input into a system.

The simplest device so far announced for reading handwritten characters was invented by Tom Dimond

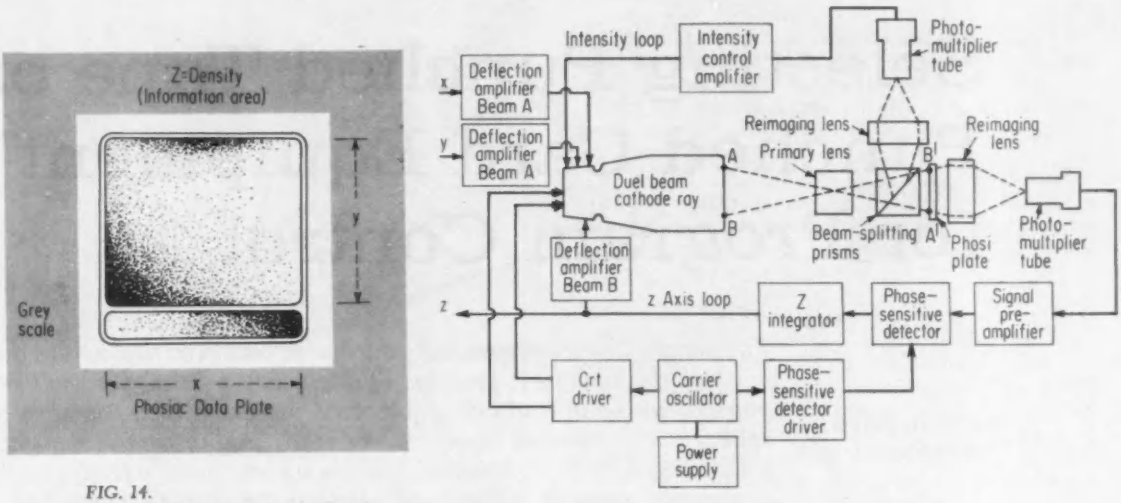


FIG. 14.
Phosiac function generator developed by Steven Douglas Co. generates function of three variables (see text).

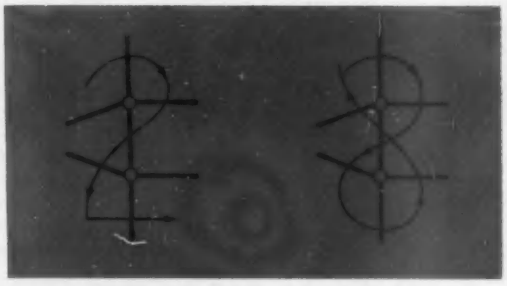


FIG. 15. This simple pattern of seven conductive lines and some logic circuitry can recognize handwritten numerals by sequence in which lines are crossed.

of Bell Telephone Labs. It uses a small printed circuit of seven conductive lines in the pattern shown in Figure 15, each line connected to logic circuitry. The logic is arranged so that the sequence of lines crossed in writing a numeral selects the correct circuit for that numeral. This circuit can then transmit a code for the numeral written to other equipment. A somewhat more complex pattern is required to code handwritten letters automatically.

Note that the same line sequence is crossed by the numeral eight as the numeral two, but that the eight continues to cross three more lines. This means that the numeral two is an intermediate step in the formation of numeral eight. There is no difficulty in identification, however, for the signal circuit selection is not made until the special stylus or pencil is touched to an "erase" plate. The device can also recognize numerals previously written with a conductive lead.

The logic circuitry for reading previously written numerals is considerably more complex than that for reading numerals as they are being written, since no advantage can be taken of the sequence in which the lines are crossed. The circuitry cannot be used to read previously written alphabetic characters.

The numeral readers developed by Stanford Research Institute, one of which is described in some detail in CONTROL ENGINEERING for July 1958, pp. 79 ff., require that the numerals be printed with a special magnetic ink. Therefore, although they are readable by machine as well as by human bank tellers, they involve special preparation equipment and so are not in the same category with Dimond's device.

Very much more sophisticated attempts at character reading have been made with some success by Solartron Electronic Corp., Ltd., of England and Intelligent Machines Research Corp. in this country. Both of these machines use scanning devices. Solartron's ERA (Electronic Reading Automaton) uses cathode-ray-tube scanning to compare observed patterns against patterns stored in a matrix. Operation of the ERA and some of its signal-to-noise problems encountered were described by its designer, C. E. G. Bailey, in CONTROL ENGINEERING for May 1958, pp. 137 ff. A machine designed by IMRC has been on trial operation at an Illinois telephone company office for some time. It uses a Nipkow disc to scan characters.

The primary difficulty being experienced with character reading machines so far stems from the signal-to-noise problem. Both the Solartron and the IMRC machines are designed to reject characters as unreadable if a check against the pattern stored in the matrix indicates that it could be more than one character; the machines are not permitted to guess. For this reason, the characters which they do read are nearly 100 percent correct. But at present they are rejecting something in the order of 20 percent of all the documents read, while Stanford's magnetic numeral reader by contrast rejects less than three-fourths of a percent of all checks.

Selecting Punched Tape or Punched Card Equipment for Program Control

LEWIS H. YOUNG
Control Engineering

The punched media—tapes and cards—serve best in control applications in which the program is variable. This article first discusses when to use punched media in controlling automatic processes; then considers the application of punched tape versus punched card to control sequential operations. Finally it describes and compares commercially available equipment—punches, readers, and accessory equipment—that a designer can choose for a particular application.

In a battery manufacturing plant, a punched tape-controlled machine automatically seals 60 different sizes of batteries, without human help. After an electric eye identifies the type of battery entering the machine, the roll of punched tape is searched for the proper program perforated on it. Then the machine applies plastic material, following a path dictated for the particular battery by the previously punched out schedule—and readies itself for the next battery.

Punched input media lend themselves to this type of control application—a variable program that changes with a change in product. Today, both punched cards and punched tape find considerable use in machinery and process control, including punched card control of automatic inspection, card programmed reversing roughing steel mills, batch mixing and tape-controlled machine tools.

Selection of punched media among available programming techniques is influenced by these factors:

1. The type of program—if this is variable and so cannot be wired into the machine, it can be inserted on versatile and flexible punched media.

2. The type of data to be handled, prime or refined—in complex applications such as continuous contouring control, punched media are frequently chosen to carry raw or prime data (information that requires manipulation or computation such as interpolation). Because of the manipulation, raw data can be inserted into the control system at a deliberate rate. Magnetic tape, on the other hand, is often preferred for secondary or refined data, which may contain the actual control signal. Magnetic tape's major attributes for this application are high packing density and its ability to carry a continuous signal.

3. Method of preparing data—if input data is prepared manually, punched media are preferred. The punched card or tape provides a visual means of checking what is being done.

4. Speed of data handling—punched cards and tape work best in applications that require the insertion of input data at slow or moderate speeds. If information has to be inserted at very high speeds, many of the punched media readers are usually unsatisfactory.

5. The application—choice of a programmer also depends on how and where it is to be used. Elements such as cost, maintenance, and reliability are important, too. In general, cost of punched equipment is moderate to high (compared to other forms of programmers); some of it has operated with practically no maintenance, but some needs constant care for satisfactory performance; some punched media control has proven unusually reliable even in extremely severe service.

CARD OR TAPE?

Once it has been decided to use a punched media programmer, a new question arises: punched cards or punched tape? There are three important considerations: First, should the input data be inserted in parallel or serial form? Second, what kind of data processing equipment (if such is necessary) is available to the user to prepare cards and tape? And third, how much can the user afford to pay for the system?

• Information input—When data has to be inserted in parallel, designers have preferred punched cards, because all the data on a card is almost always read simultaneously, while punched tape is usually read a line at a time. However, the development of block-tape readers, capable of reading 10 lines or more at one time, has extended the usefulness of tape.

But the punched card has an advantage: it can insert a large amount of information practically instantaneously. This allows a controller to digest a large piece of information at one time. For example, an 80-column card with 12 bits per column can inject up to 960 bits of information at one time, while a punched tape reader would have to scan 100-in. of eight-hole tape.

• Data processing equipment—If a computer is required to prepare the input information, the programmer is frequently chosen to be compatable with the computer output. That means if a user has a computer that turns out data in punched-card form, his best bet is to use a punched-card programmer; or,

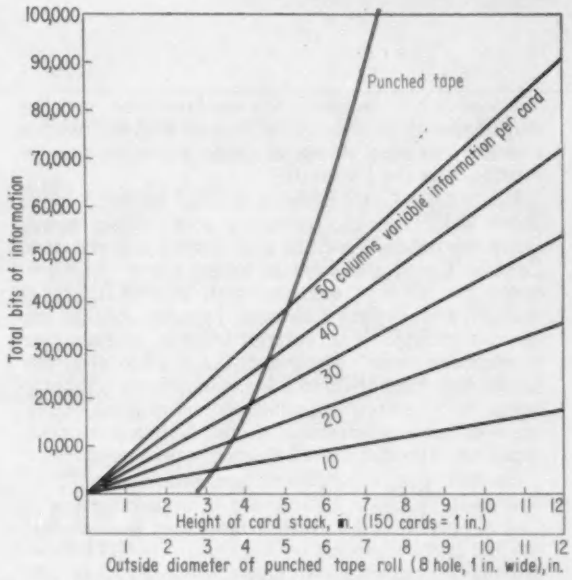


FIG. 1. Storage Capacity of Punched Tape Versus Punched Cards.

if the computer output is printed in tabular form, to use punched tape.

• Economics—In general, punched-tape equipment costs considerably less—to do the same job—than punched card gear. For one thing, it is usually simpler in design. Punched card equipment almost always has built-in checking circuitry (internal parity checking, sequence checking, etc.), all of which adds to electrical complexity. And punched card devices are usually more complicated mechanically. The greater simplicity of tape equipment design tends to reduce required maintenance and increase reliability.

Another factor is the availability of a large number and variety of building block components for tape control. For example, it is possible to buy a tape reader that is a simple, clutch-controlled device even without drive motor, power supply, or timing cams (price about $300); or a high-speed reading unit, complete with all operating accessories (price about $3,000). The situation is quite different for card readers. There are very few "pure" static card readers commercially available. The usual practice is to buy a card-tabulating unit (price about $3,500) and then modify it for control purposes.

Although punched cards can insert more information at one time than punched tape, the storage capacity of eight-hole tape is about equivalent to 80-column cards. In eight-hole tape, with 10 lines to the inch, it is possible to store 80 bits (8 x 10) per linear inch. The punched card can store 960 bits (80 x 12) per card or 40 bits per sq in. The storage capacities of cards and eight-hole tape are compared in Figure 1.

Punched tape is easier to transport than decks of cards. There's no risk of scrambling the program if the tape is dropped—a continual hazard with card decks. However, the ability to readily rearrange the deck can also be an advantage. Replacing one card or group of cards with another to alter the program or bring it up to date is a simple matter. To change the tape it *is* necessary to cut the tape and insert a new section.

Tape also seems able to bear up better under manufacturing conditions. Cards are more sensitive to changes in humidity, temperature, and soil and wear, changes that can affect accuracy and readability. Because the usual tape is only an inch wide, and is held rigidly by two metal bars when it is read, it is less affected by environmental changes. However, both plastic tape and plastic cards are available for use whenever environment is a serious problem.

In general, tape appears to have the advantage in repetitive operations and/or in supplying blocks of information. However the difficulty of incorporating changes to the program, compared to altering punched card programs, is a disadvantage.

PUNCHED TAPE

Because of its flexibility and relatively low cost, punched tape is enjoying considerable popularity as a program medium in control applications. There's considerable experience behind this use, much of it amassed from the communications industry, which has used punched tape since midway in the 19th century. Between 1906 and 1926, the Morkeum-Kleinschmidt printing telegraph system was developed, using a five-hole code invented in the 1850's by Baudot.

In control applications a variety of tape sizes have been used, including seven-hole, eight-hole, 12-hole, and up to 85-hole. Tape width can vary from less than 1 in. wide to 8 or more in. And, the machine builder has developed special equipment to use them. For example, the R. K. Le Blonde Machine Tool Co. uses a 0.005-in.-thick Mylar plastic tape, 4¾ in. wide with at least 24 $\frac{3}{32}$-in. diameter code holes on a line. Jones & Lamson Machine Co. employs Mylar tape too; it's 0.002 in. thick, 4$\frac{1}{16}$ in. wide, and carries 32 $\frac{3}{64}$-in. diameter potential code holes per line. A 0.003-in.-thick bond paper tape, 3$\frac{7}{16}$ in. wide, is used by Pratt & Whitney Corp.; it has 12 $\frac{3}{32}$-in. diameter code holes per line. Still another variation controls Lavoie Laboratories' automatic testers and IBM series 400 tabulators. Called programatic tape, this is 1.625 in. wide, and contains 12 0.084 x 0.070-in. code discs per line.

Such variety complicates tape-equipment selection and multiplies the users' problems. It's conceivable that a plant could have x numbers of tape-controlled machines, each using a different size tape. To forestall such a possibility, the industry (through an EIA subcommittee) is attempting to standardize tapes for control purposes. The proposed standard: an eight-hole tape, 1 in. wide, with sensing holes 0.072 in. in diameter, feed holes 0.046 in. in diameter.

Eight-hole tape permits 255 possible variations for representing characters. This, most industry observers feel, is enough versatility for the designer to produce any code necessary. Wider tapes have been used primarily to simplify the coding problem; but the tape industry feels that enough is now known about coding to allow standardization at 1 in. (for more on coding, see page 146). Most of the tape equipment described here works with eight-hole, 1-in. tape.

In a punched-tape system, at least two key pieces of equipment are always necessary: a punch to make the programmed tape and a reader to convert the perforated coding into control signals. A user may also have equipment to help prepare the tapes: calculators, computers, printers, etc. For example, the tape may be prepared from a manuscript as a by-product while the manuscript is being typed on a special typewriter, such as the Commercial Controls Corp. Flexowriter. A Flexowriter

Friden Co.



FIG. 2. Combination calculator and tape punch (Friden Model B Computer is shown) prepares tape programs that require some computation. This unit costs about $4,750. Others are made by Monroe Calculating Co. and Clary Corp.



FIG. 3. New card-to-tape converter fits on Flexowriter, permits rapid preparation of punched tape as well as simultaneous printout of hard copy.

Commercial Controls Corp. Div. of Friden Co.

with built-in punch and reader can be purchased for from $2,500 to $3,000, depending on additional features requested.

Special verifying punches are available to check the program perforated on a tape. And duplicating equipment is available to make multiple copies of a punched tape. A great deal of commercial punching equipment can be supplied at additional cost with verifying and/or duplicating attachments.

Punches

Selecting a tape punch is not as critical as choosing a tape reader. That's because the punch is usually located away from the machine (frequently in the data processing section, accounting or tabulating department), so there is no fitting the punch onto the machinery. Speed of preparation of control tapes is often not an important factor. As a result, the punch is usually selected on the basis of cost—the lowest cost compatible with preparing the tape efficiently. Punches can be classified into three main groups: 1) manual perforation, 2) keyboard or 3) automatic operation.

The manual punch can be as simple as the one offered by ElectroData Div. of Burroughs Corp. The tape fits under a template with eight holes. The operator perforates the medium by pushing an awl-like tool through the proper hole. The unit's main job is positioning the tape accurately. It can handle five-, six-, seven-, or eight-hole tape; costs about $40. To use such a device the operator receives the program already coded with a plan of where the code holes should be for each line. He then converts the plan to tape. The unit can also be used to repair and correct tapes. Its main use is with a limited number of code groups in small operations.

Commercially available keyboard-operated punches range from a combination of a small keyboard with a motor driven punch to an automatic typewriter arrangement such as the Flexowriter.

ElectroData Corp. makes a decimal keyboard (price about $145) that can operate a motor-driven punch (price about $650) such as that made by Commercial Controls Corp., a division of Friden Corp. The keyboard has 10 keys engraved with decimal digits, 0 through 9, and three additional keys for optional engraved markings. The operator requires program data in numerical form. The punch (CCC's Model 2) can handle tape from $\frac{1}{4}$ in. to 1 in. wide (five- to eight-hole tape). It is a completely self-contained machine requiring only cable connections to the keyboard or other apparatus. Speed: up to 20 characters per sec.

Another type of keyboard tape punch is built by California Technical Industries. It is an extension of manual operation: the operator must have the code laid out just as it will appear on the tape. The CTI Tape-Ard Punch perforates 1-in. tape (eight-hole) using conventional $\frac{1}{10}$-in. hole spacing. The operator sets up a line on eight pushbuttons (pushing a button in the line where the hole is desired), then pushes a command button to operate the electric-powered punch. The tape advances when punched and a counter indicates the number of lines that have been completed. This unit can be purchased with a CTI reader coordinated with the punch so that copies of tape can be reproduced at rates of up to 900 lines per min. The machine can then be switched from automatic to manual at any frame to insert new or corrected information.

Soroban Engineering, Inc. makes a tape punch that will handle five-, six-, seven-, eight- and 16-hole tape (two eight-hole tapes side by side) from manual keyboard entries. It's available with a choice of keyboards: decimal or alphabetic. Maximum speed of the unit is 15 characters per sec. It, too, can be equipped with a Soroban Reader for verifying or duplicating tapes. Choice of the code dictates which keyboard is used.

The most sophisticated of the keyboard-operated tape punches are those run by typewriters. The Flexowriter Programatic is probably the best known. Other makers of electrically powered punches sometimes use an electric typewriter in conjunction with the punch. (Soroban, for example, offers such a combination.) Because of the versatility of the keyboard—it contains both letters and numbers—the widest range of codes can be prepared. Costs of such units depend on the features requested. It is possible, for instance, to perforate a tape with a Flexowriter and operate a remote motorized punch at the same time. These units usually are equipped with a reader to verify and/or duplicate tapes.

The biggest group of automatic tape punches are the card-to-tape converters. Relatively expensive devices (priced at about $8,500) are made by IBM, Sperry Rand, Inc., Epsco, Inc., and General Cybernetics Corp. Major use occurs when data has to be prepared in a computer whose output is a punched card. The card output is then converted to control tape. Commercial Controls Corp. has just announced a low-cost attachment (price about $2,000) for the Flexowriter to convert punched-card and punched-tape data. This unit operates at a speed of 20 characters per sec.

A new, high-speed, motor-driven punch built by Soroban operates at rates up to 240 characters per sec

SOME MANUFACTURERS OF PERFORATED RECORD EQUIPMENT

I PAPER TAPE PUNCHES

Barnes Engineering Co.
Stamford, Conn.
California Technical Industries
Div. Textron, Inc.
1476 Old Country Road,
Belmont, Calif.
Commercial Controls Corp.
1 Leighton Ave.,
Rochester 2, N. Y.
ElectroData Div.
Burroughs Corp.
Pasadena 6, Calif.
Ferranti Electric, Inc.
30 Rockefeller Plaza,
New York 20
Friden, Inc.
San Leandro, Calif.
Hillyer Instrument Co.
54 Lafayette St.,
New York 13
Kleinschmidt Labs, Inc.
Deerfield, Ill.
Lavoie Labs, Inc.
Keyport, N. J.
LeBlonde, R. K. Mach. Tool Co.
Cincinnati 8, Ohio
Pratt & Whitney Corp.
West Hartford 1, Conn.
Soroban Engineering, Inc.
Box 117, Melbourne, Fla.
Tally Register Corp.
5300 N. W. 14th Ave.,
Seattle, Wash.
Telequipment Corp.
Sea Cliff, N. Y.
Teletype Corp.
1400 Wrightwood Ave., Chicago
Teletypesetter Corp.
2752 North Clybourn Ave.,
Chicago 14

II PAPER TAPE READERS

California Technical Industries
Div. Textron, Inc.
1476 Old Country Road,
Belmont, Calif.
Commercial Controls Corp.
1 Leighton Ave.,
Rochester 2, N. Y.
Digitronics Corp.
Albertson Ave., Albertson, N. Y.
ElectroData Div.
Burroughs Corp.
Pasadena 6, Calif.
Ferranti Electric, Inc.
30 Rockefeller Plaza,
New York 20
Kleinschmidt Labs, Inc.
Deerfield, Ill.
Lavoie Labs, Inc.
Keyport, N. J.
LeBlonde, R. K. Mch. Tool Co.
Cincinnati 8, Ohio
Monroe Calculating Mch. Co.
Orange, N. J.
F. L. Moseley Co.
409 N. Fair Oaks,
Pasadena 3, Calif.
Potter Instrument Co., Inc.
Sunnyside Blvd.,
Plainview, N. Y.
Pratt & Whitney Corp.
West Hartford 1, Conn.
Soroban Engineering, Inc.
Box 338, Melbourne, Fla.
Teletype Corp.
1400 Wrightwood Ave., Chicago
Teletypesetter Corp.
2752 N. Clybourn Ave.,
Chicago 14

III TAPE-TO-CARD CONVERTERS

Austin Co.
76-9th Avenue,
New York 11, N. Y.
IBM Corp.
590 Madison Avenue,
New York 22, N. Y.
Sperry-Rand Corp., Inc.
315-4th Avenue,
New York 10, N. Y.

IV CARD-TO-TAPE CONVERTERS

Epsco, Inc.
588 Commonwealth Ave.,
Boston, Mass.
General Cybernetics Corp.
Box 987, Beverly Hills, Calif.
IBM Corp.
590 Madison Ave., New York
Sperry-Rand, Inc.
315-4th Ave.,
New York 10, N. Y.

V PUNCHED CARD MACHINES

Analog Controls, Inc.
Mineola, N. Y.
British Tabulating Mch. Co., Ltd.
17 Park Lane, London, W 1,
Eng.
Bull S A Compagnie des Machines
94 Avenue Gambetta, Paris
Commercial Controls Corp.
1 Leighton Ave.,
Rochester, N. Y.
Dennison Mfg. Co.
Framingham, Mass.
E. Z. Sort Co.
San Francisco, Calif.
Film Sort, Inc.
330 West 42nd St., New York
General Cybernetics Corp.
Box 987, Beverly Hills, Calif.
General Precision Laboratory
63 Bedford Road,
Pleasantville, N. Y.
IBM Corp.
590 Madison Ave., New York 22
A. Kimball Co.
444-4th Ave., New York 13
Metron Corp.
8 Coryell St., Lambertville, N. J.
Moseley, F. L. Co.
409 N. Fair Oaks, Pasadena 3,
Calif.
Powers-Samas Acc'ty. Mch. Co., Ltd.
London, England
Royal McBee Co.
Hartford, Conn.
Remington Rand Univac
Div. of Sperry-Rand Corp.
315-4th Ave., New York 10
Underwood-Samas Corp.
1 Park Ave., New York 16,

on five-, six-, seven- or eight-hole paper or parchment tapes. It has no input device; the user must supply some method—punched card, tape, magnetic tape—for driving the device. As a general rule, the higher the speed the more associated equipment is required—and so the higher cost. Other companies that make high-speed punches are: Kleinschmidt Labs., a division of Smith-Corona, and the Teletype Corp.

A list of manufacturers of paper tape punches appears at left. This list is not complete and includes some companies that have built special units.

Tape Readers

Choosing a tape reader is a more difficult job. Choice depends on speed at which information must be inserted, the cost of the unit, the environmental conditions in which it must operate, and how the reader can be incorporated in the machinery to be controlled.

There are two main classifications of readers, line readers and block readers. As the names imply, the line reader scans one line at a time; the block reader simultaneously reads several lines.

Line readers use a mechanical pin, an optical system, or pneumatics to read tapes. The mechanical-pin type was the earliest developed. Here's how it works. A line of pins are raised against the tape; where code holes appear on the line, the pins pass through the tape and actuate electrical contacts to close a circuit. Because the operating principle of the pin-through-the-hole reader is so simple, these devices require little maintenance, tend to operate trouble-free. However, their speed is slow, because the tape must be stationary during actual reading, thus can move only intermittently. The reader reads at rates ranging from 15 characters/sec to 60 characters/sec.

Manufacturers of pin readers include Commercial Controls, Soroban Engineering, and Clary Corp. The

Soroban Engineering Inc.

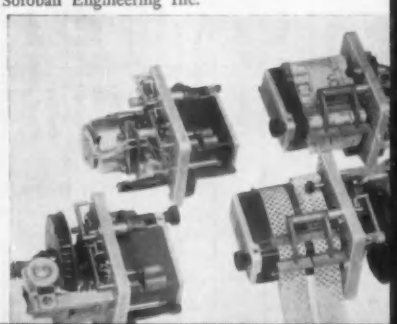


FIG. 4. Solenoid driven tape readers operates up to 45 characters per sec. During reading, sensing pins close reading contacts during the solenoid energized stroke, and contacts remain closed until the drive solenoid is de-energized.



FIG. 5. Block reader (CTI Model 171) reads 10 rows of 8 holes each simultaneously. Motor clutch mechanism advances tape at high speed—35 milliseconds required to move one frame.

California Technical Industries

CHARACTERISTICS OF PUNCHED TAPE READERS

READER	FEED	SPEED	READING MODE	MOUNTING	COST	ADVANTAGES	LIMITATIONS
Commercial Controls Corp. Model 2*	Strip or reel	20 cps max	Mechanical pin	Cabinet	$650	Low Cost; old, proven design; very flexible	Low speed; contacts require maintenance
Soroban Engineering Inc. Model FR 310S FR 310M FR 310XM	Strip only	18 cps 30 cps 45 cps	Mechanical pin Solenoid-driven Motor clutch-driven Motor clutch-driven	Plug-in Panel or cabinet Panel or cabinet	$740 $850 $960	Higher speed than usual mechanical readers	Relative high cost for mechanical reader; intermittent tape feed has been a problem
Ferranti	Strip only	200 cps	Optical; Pin hole projection; vacuum photo cells	Cabinet	$1,500 (without take up spools $285 each)	High speed; good mechanical design	Critical optical assembly requires regular cleaning and adjusting
Potter Instrument Co.	Reel only	600 cps	Optical; direct photo diode	Rack	$3,000 (Model 903 JC with reel servos)	High speed; excellent braking; bidirectional	Relative high cost because of extra features
Digitronics Corp. (Dykor)	Strip or reel	200 to 750 cps	Optical; direct photo diode	Rack	$1,210 (Model SC-201A, no reel servos)	Versatility; available in a variety of models with different speeds, components and accessories; bidirectional	Can't stop between characters when speed exceeds 250 cps
California Technical Industries	Strip	10 row block; 15 blocks/sec	Brush	Rack	$1,800	High speed; block reading reduces shift register required and other memory circuits	Low tape life; may require plastic tapes
Wang Laboratories Inc.	Strip	11 row block; 10 blocks/sec	Brush	Prototype	Est. $2,000	High speed; eliminates use of shift registers or other memory circuits	Low tape life; may require plastic tapes

*Available as a clutch-controlled reader without drive motor, power supply or timing cams; approx. price $300.

CCC unit (Model 2 reader) normally is bought as a packaged unit (width 12½ in., height 6½ in., depth 19½ in.) with a built-in motor-drive, power supply, and timing cams, but is also available by itself. It uses a magnetically-operated, single revolution clutch to drive the camshaft of the reader. Control impulse for the clutch magnet should have minimum duration of 15 millisec, minimum current of 0.090 amps to operate the clutch magnet. Standard driving speed of the reader is 1,200 rpm. The CCC unit will read five- to eight-hole tape, 0.687 to 1.000 in. wide; hole size is 0.072 in. diameter for code holes, 0.046 in. diameter for feed holes.

Soroban's three pin-type readers have these maximum operating speeds: 1) 18 lines per sec, 2) 30 cps, and 3) 45 cps. In the slowest unit, rotary solenoids serve as the driving force for the reading head. The higher-speed units are motor-clutch driven. Reading heads are available in two sizes: for single tapes five-, six-, seven-, or eight-hole, or for wide tapes (up to 16 or 28-hole tapes). When reading dual tapes, the reader transports the tapes as if they were a single wide tape. Such units are usable in dual functional control applications, where information recorded on one tape controls the routing of information recorded on a second tape. All three Soroban units can be purchased in cabinet mountings or in panel mountings.

Close to 50 characters per sec has been the highest reading rate that pintype readers can achieve. To do better, designers have developed the optical or photo reader. This reads the tape while it is in motion, is said to reach operation rates as high as 750 characters per sec. These units cannot stop between characters when reading at rates above 200 characters per sec because of the time required to operate the clutch and brake mechanism. If such a reader is used, associated circuitry must be adequate to consume the read data.

Major suppliers of optical readers are Digitronics Corp., Potter Instrument Co., and Ferranti. Both Digitronics (Dykor Reader) and Potter use a direct-reading optical system—light passing into a photo diode through a code hole. Potter employs germanium diodes, Digitronics, silicon which it claims are temperature insensitive. The Ferranti system uses a pin-hole camera to project the light beam into a vacuum-tube photocell. There is some indication that this camera arrangement requires regular adjustment because dirt tends to clog the pin hole.

Both the Potter and the Dykor unit have one other interesting capability: they are bidirectional, and thus particularly applicable when a program requires automatic search or repeat feedings.

A number of readers use air or vacuum to read the tape. Most of these pneumatic devices were developed for special application or are still in the prototype stage. As a rule they are simple, reliable, and operate at speeds up to 50 characters per sec. However, they require an air supply or vacuum system, and considerable circuitry.

To overcome limitations of tape imposed by sequential reading, so-called block readers have been developed to read eight to 32 lines at a time. Reading blocks in parallel reduces the amount of storage circuitry and associated equipment. The tape passes through a long sensing area, so that a predetermined length of tape is under the reading head. When the tape stops, sensing pins or brushes are raised; these pass through perforated

code holes and close electrical circuits. Though experience with block readers is still limited, it has been established that accuracy of holes location in the tape is critical and longitudinal spacing errors can occur when the tapes are punched sequentially. Therefore, punches have to be adjusted carefully. In addition, the tape material requirements for stability, allowing minimum dimensional change with changes in temperature and humidity, are more severe.

The block reader built by California Technical Industries reads 10 rows at a time. Called the Tape-Ard Reader, it scans 1-in., eight-hole tape. Tape advances from one 10-line frame to the next in 35 millisec. Maximum operating rate is six frames per second (up to 15 frames per sec for short periods). The unit has a built-in verifier in which neon lamps, set up on an 8 x 10 grid, duplicate the hole pattern.

A unit by Wang Laboratories, Inc., uses brushes for reading 12, 16 or 20 lines at a time.

PUNCHED CARDS

The bulk of punched-card-controlled applications use either an 80-column IBM card, 12 lines per column; or a 90-column Sperry Rand card, with 6 punching positions per column. The two systems are not compatible. IBM perforates the coder with a rectangular opening; the Sperry Rand system uses a ¼-in.-diameter hole. In some applications an edge-punched card has been used as the programmer, but this card has limited information capacity.

Once a punched-card system has been chosen, all equipment must be compatible. Frequently punched-card equipment is rented rather than purchased; in this case maintenance is usually contracted. However, if changes are made in the equipment by the user, the equipment must be purchased.

Card preparation—like tape preparation—can be manual, semi-automatic, or automatic, IBM, for example, makes a mechanical punch that pushes out embossings in a previously punched card. Called the Port-A-Punch, it sells for less than $10. Best known method of making a punched card, however, is by means of the card punch more frequently called the key punch. This device is manually operated through a keyboard, costs from $1,950 to $2,500, depending on how fast it operates and on special features. Both IBM and Sperry Rand manufacture this equipment.

Mark sensing is a semi-automatic method of card preparation. First a card is marked with a special graphite pencil wherever a hole is desired. Then it is fed into a reproducer which turns out a punched card usable for control. However, probably the commonest way of making a punched card for control applications is with associated computer equipment. The card is the main product or a by-product of a computation.

In addition, punched-tape-to-card converters (approximate price $6,500) and magnetic-tape-to-card-converter equipment (price: over $25,000) produce punched cards.

Choice of the card reader outweighs choice of a punch. Quite early in the selection process, the designer has to choose the kind of code he will use. He would usually decide between binary, a decimal, or binary coded decimal.

Card readers can be grouped into three main classes: parallel readers, dynamic readers and static readers. The parallel reader, which has not been used too widely, reads the card one column at a time. Its operation is similar to a punched tape reader that scans a line at a time. The dynamic reader gets its name from the fact that the card is in motion while it is being read. As the card moves through the reader at high speed, it's read in blocks and the information is stored in a buffer storage. In the static reader, the card is stationary while it is read.

International Business Machines Corp.



FIG. 6. Tab Card Punch (IBM Model 026 printing) or key punch puts alphabetic and numerical information into card, interprets and prints character or symbol for the punched code at top of card column punched; at rate of 17 columns per sec. Cost: about $3,200 (rental: $60 per month).

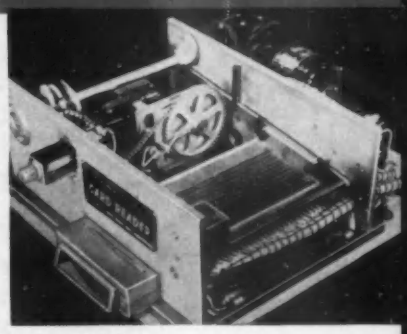


FIG. 7. Static card reader. Card remains in reader until function is completed; then new card is inserted. This contrasts with operation of dynamic reader which can read cards at rate of 150 per min.

Peerless Electric Co.

There are few static card readers on the market. IBM offers one for special purposes. IBM points out that the cost of a dynamic reader and a buffer storage frequently adds up to just about the same as the cost of static card reader.

Dynamic readers are frequently made by converting other punched card equipment which has reading capabilities. Most frequently converted: conventional tabulating equipment.

Selection of a card reader is far more complicated than tape gear, depending much more on the particular control application being studied.

The author acknowledges the assistance of a number of people and companies in the preparation of this article. Deserving particular mention because of the magnitude of their contributions are: Henry Tholstrup of Commercial Controls Corp., who as chairman of an EIA committee on standardization of punched tape media has collected large quantities of information about punched tape equipment and its use; Harry Mergler of Case Institute of Technology, who suggested areas of coverage and supplied much of the theoretical background; and representatives of the International Business Machines Co., for background on the use of punched card equipment.

Selecting a Magnetic Tape System for Program Control

DONALD HALFHILL
EDWARD WILDANGER
Ampex Corp.

For a magnetic-tape system to be of maximum value in program-controlling an automatic process—whether this process involve machine tools, chemical operations, conveyors, sorters, or automatic inspectors—the system's tape transport, magnetic heads, electronic circuits, and the tape itself must be functionally compatible. The authors describe the workings of each element and show how they fit together in program control applications.

An evaluation of the controlled system's requirements determines which of the many common forms of analog or digital signals will be used for programming. This article reviews methods of recording these signals and reproducing them from magnetic tape, and the effects each signal form has on the magnetic-tape system's own performance.

Magnetic-tape recording is probably the most versatile method of storing programs for control systems. Program information can be written into and retrieved from magnetic tape at fast transfer rates. Information signals can be in any of several pulse or continuous forms. Magnetic tape stores many tracks of data (up to 16 on a 1-in. tape) and pulses along any track can be closely spaced, with the result that such tapes have an extremely high storage capacity. In normal use, the recording is permanent to the extent that the same tape can be used many thousands of times. Since recording takes place through a change in the tape's magnetic state (punched paper tape, by contrast, undergoes a physical change), any portion of the taped program can be magnetically erased and rewritten at will.

Magnetic tape is made by coating a plastic strip with magnetic iron oxide particles held on with a binder material. Its desirable characteristics are high voltage output, low noise level, signal-level stability, long life, low wear, and low abrasion. High output signal and low noise level (a high signal-to-noise ratio) results in large dynamic range and little signal ambiguity. Freedom from signal dropouts (caused by small uncoated portions of the tape) is important, especially when pulse trains are recorded.

PUTTING PROGRAM SIGNALS ON TAPE

▶ Pulses for programming information on magnetic tape take several forms, each originating in a different way:

• Pulses of equal time duration representing characters (numbers and letters) formed by pulse combinations which serve as a program command. Because this is similar to the alphanumeric tape coding common to digital computers, magnetic tape transports and accessory electronic devices available from computer applications can be adapted to program control work. Furthermore, when digital computers are themselves used to control a machine or process, such special programs as startup or emergency shutdown recorded in this pulse-code form, Figure 1A, are readily compatible with the control system.

• Pulses representing such commands as opening or closing a valve, and starting or stopping a motor. These are pulse-duration or on-off signals; they need not be of fixed time duration but last as long as the operation is desired. Sometimes the leading and trailing edges of the pulse are converted to spikes or pips to define pulse duration, Figure 1B; at other times the pulse is recorded as a tone burst that produces an ac signal on readout.

• Pulses representing the value of a continuous (analog) signal sampled at an instant in time. Ways of converting such signals to pulses are described below.

▶ Signals varying continuously with time can be stored on magnetic tape by means of:

• Direct analog recording, Figure 1C, in which tape-magnetization amplitude (and hence the readout voltage signal) is proportionally related to the signal at each instant of time. Direct recording is simple and requires a minimum of equipment to write and read the signal. However, it suffers from poor signal-to-noise ratio, limited response at low frequencies, and limited accuracy due to magnetic nonlinearities in the tape.

• Modulation-recording techniques; there are two categories:

1. Sinusoidal-carrier techniques—In amplitude modulation the original continuous signal is imposed on, or

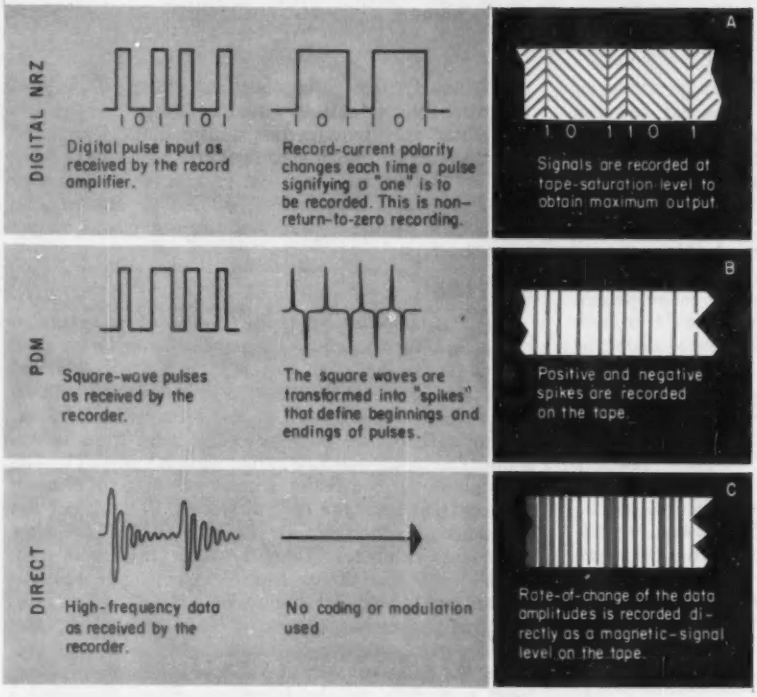


FIG. 1. Some of the common ways of putting program signals on magnetic tape.

modulates, a fixed high-frequency constant-amplitude carrier. The resulting signal as recorded on the tape is then a high-frequency signal whose amplitude varies directly with the instantaneous amplitude of the continuous signal. On readout from the tape, a demodulating circuit removes the carrier and restores the signal to its original continuous form. Amplitude modulation results in better low-frequency response than direct recording, but nonlinearities reduce accuracy. In frequency modulation the carrier frequency changes in relation to the continuous signal. This technique affords good frequency response (down to dc) and linearity characteristics for the measured signal. Phase modulation of a carrier frequency offers about the same characteristics as frequency modulation.

2. Pulse-carrier techniques—In pulse-amplitude modulation the continuous signal is sampled, and the height of the pulse is proportional to the analog value at the measuring instant. Inhomogeneities in magnetic characteristics may introduce nonlinearities. Pulse-frequency and pulse-phase (or pulse-position) modulation are similar to sinusoidal frequency and phase modulation, but pulses fully saturate the tape. In pulse-duration (pulse-width) modulation the leading and trailing edges of a pulse occur at a time interval proportional to the analog value at the instant of measurement. In pulse-code modulation the continuous signal is again sampled and the pulse representing the instantaneous value is converted to a binary digital code, a series of two-state pulses saturating the tape and corresponding to the measured value. Thus, pulse-code modulated signals are in the same form as PDM.

Figure 2 represents a portion of a seven-track magnetic tape. Here, the bit is the fundamental unit in the binary pulse-code system, **1** and **0** meaning the presence or absence of a saturating pulse. In general, bits form characters, characters form words, and words are combined to form records. A group of related records constitutes a file. As shown, all seven tracks are read simultaneously transversely (parallel) across the tape, reading out one character at a time. But a train of pulses can also be entered and read serially along one track of the tape to form characters and words. Moreover, each track can be used separately for signals in other pulses and analog forms.

With pulse saturation, the read head need only distinguish between two magnetic states on the tape; the result is large and easily detectable outputs. Figure 3 shows four ways of saturating a magnetic tape with serial pulses representing bits. In return-to-bias (*RB*) recording, Figure 3A, saturation in one direction is a **1** and negative saturation (or some other bias level) is a **0**. The pulses shown are for the binary number **0110111**. Because no pulse occurs for **0** at the read head, *RB* recording must be interrogated by a clock system of timed pulses to read the number out correctly.

The same binary number is shown in Figure 3B for return-to-zero (*RZ*) recording. Note that here a pulse occurs for each and every bit, whether a **1** or a **0**, since positive pulses represent **1**'s and negative pulses **0**'s. This form of recording has the advantage of carrying its own clock.

Two varieties of non-return-to-zero (*NRZ*) record-

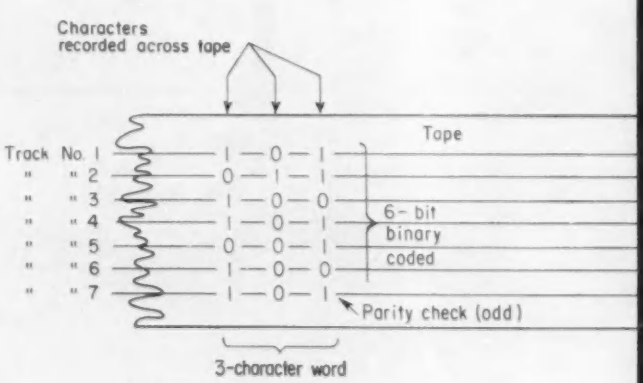


FIG. 2. This representation of a magnetic tape defines bits, characters, and words.

ing are shown in Figures 3C and D. Interpretation of their magnetic pattern is different from *RB* and *RZ* recording. In the *NRZ* (mark) method a 1 is represented by a change of magnetic state and a 0 as no change of state. In the *NRZ* (change) method the tape remains at positive saturation for 1's and changes to negative saturation only when one or more 0's occur in the pulse train. The *NRZ-M* method appears to offer the best reliability for storing information. Both *NRZ* methods permit more information to be packed on a given length of tape than does either *RB* or *RZ*, because the fewer magnetic flux reversals occurring in *NRZ* when representing bits in a character mean that pulses can be packed closer together on the tape.

Packing density defines the closeness with which bits can be serially recorded on a single track. The present conservative figure quoted in the computer industry is 200 bits per in., although newer models of magnetic tape systems may achieve densities of 400 bits per in. or higher. For program control work, however, a practical maximum density is 100 bits per in. to insure positive unambiguous reading.

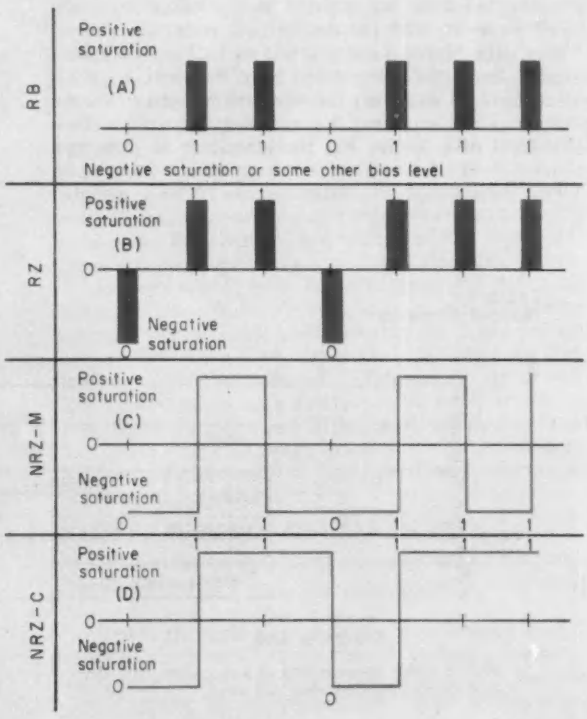
The data-transfer rate is a function of bit-packing density and tape speed:

$$R = CS$$

where: R is transfer rate, bits per sec
C is packing density, bits per in.
S is tape speed, in. per sec

Thus, 100 bits per in. at 7½ in. per sec yields 750 bits per sec. One track of a standard 2,500-ft magnetic tape can store (at 200 bits per in.) over 1.5 million bits. If characters are parallel recorded across the tape, as in Figures 1, then C becomes characters per in., and the data transfer rate is stated as characters per sec. Computer work requires fast transfer rates, hence fast tape speeds. In program control of a machine or process, fast transfer rates may not be necessary. Fast tape speed, however, may still be needed to obtain rapid access to a particular part of a program stored on the magnetic tape.

FIG. 3. Four ways to record digital signals on magnetic tape.



BUFFERS

Pulse data stored on tapes consists of programmed commands for the control system. As the read head serially scans the tape it detects individual bits and characters in a frame. Because one frame may not contain sufficient intelligence in the form needed by the control system, the pulse record is read from several frames on the tape and accumulated in a buffer. Then all information in the buffer is read out in parallel upon interrogation from the control system, to carry out the called-for operation. Such an arrangement can slow down data being read from the tape (making it compatible with the slower control system), in addition to the serial-to-parallel conversion.

When a program command is contained in one frame, when a magnitude-of-flux-level head is used, and when the transport can precisely stop the tape so the head is directly on the frame containing the desired program, the auxiliary buffer need not be used.

To see how a buffer operates, consider this typical problem: a certain condition at the controlled system establishes signals constituting an address on the tape; at this address is a record containing the programmed corrective action to be taken when the condition arises. The signals initiate a rapid search for the proper address. When the tape arrives there, the record is read out to the buffer, made up of magnetic cores, flip-flops, or a magnetic drum. The buffer output then actuates valves (or relays or motors) to effect the necessary corrective action. An external latching arrangement could keep the valves in their commanded positions, clear the buffer, and permit the tape to go on standby, ready for a new search.

TIME DISPLACEMENT ERROR

It is essential that all data recorded simultaneously on tracks across the tape be read within close time proximity of each other, because any difference between arrival time under the magnetic head results in time-displacement error, *TDE*. If large enough, *TDE* causes bit crossover from one frame into the next, Figure 4. Widening the frame to minimize *TDE* limits pulse-packing density, and thus the amount of information stored on a tape. Generally, *TDE* will have no effect on the external system (buffer) operated by the magnetic-tape programmer if it does not cause bit crossover. But some systems may demand that all information be read out in a short portion of the overall frame length. Since this effectively shortens the frame, it increases the possibility of bit crossover.

Time-displacement error results from poor tape guiding, slitting errors, gap scatter within the head stack, nonperpendicularity of the line of head gaps with respect to tape motion, and errors in threshold detection due to amplitude changes of signal from the tape. Late detection of a small amplitude pulse also adds to *TDE*.

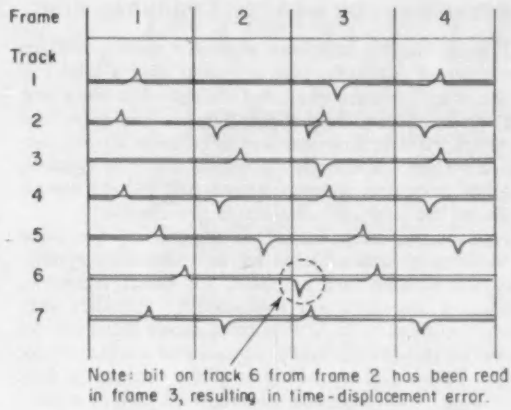


FIG. 4. When time-displacement error is large enough, a bit crosses over into the next frame, producing an erroneous program command.

A clock system can be used to great advantage in eliminating *TDE* of pulse-recorded data. One tape track (usually the center one) carries a clock signal to operate a clock generator. Signals from each data track set up an output translator for its track. At some time after the reading operation, the clock-generator signal causes all output translators to emit their pulse (if any) simultaneously, reading out all bits in the frame and resetting the translators for the next frame. (The clock signal to the clock generator may also originate, for tapes without a clock track, from the first bit read in the frame.)

TAPE TRANSPORT MECHANISMS

A transport drives the tape at uniform tension and uniform speed across the magnetic head. Takeup and supply reels have tensioning devices that insure proper supply and takeup of tape. In many analog systems, tape speed variations are compensated by servo speed control.

Even with servo compensation, tape-speed variations do occur, and the amount permissible differs for continuous or pulse signals. Speed variations introduce erroneous signals or noise in the control system. Low-frequency variations, termed wow, result from line frequency changes or inaccuracies in the tape drive. Variations below 20 cps, for instance, can create resonance in tool servos of program controlled machines. High-frequency variations, termed flutter, are caused by vibrations of the tape itself. In general, transports for handling analog signals of any type are designed to have extremely good timing accuracy. For digital signals, flutter and wow are compromised in favor of the rapid start/stop times needed for readout information at nonuniform intervals and for furnishing information upon command from the control system.

Tape skew, caused by a slight misguiding of the tape as it passes over the reproducing head, causes a time-displacement error between tape tracks. As mentioned previously, *TDE* may cause a bit crossover resulting in a drastic error for digital signals. Skew may also cause a time or phase shift between tracks containing continuous signals, and this shift may lead to a significant system error, depending on the controlled system's speed of response. System design considers this and eliminates the problem by proper choice of bit density and tape guiding means.

Tape transports designed for program control must contend with environmental conditions different from those encountered in a laboratory. Satisfactory performance must take place under extremes of temperature and humidity, and in the presence of such contaminating agents as oils, greases, abrasive dusts, and vapors. Some users report operation in excess of 16 hours daily, seven days a week. This would wear out machines not specifically designed for such service. Personnel operating the equipment are not necessarily of technician caliber, and the human engineering aspects of transport design therefore become quite important: controls should be few and adjustments unnecessary.

Two kinds of wear take place as the tape moves past the transport's magnetic heads, guides, and idlers: the tape wears the transport and the transport wears the tape. Minute particles of iron oxide and plastic binder are worn off and deposited on the various elements of the transport. Good instrumentation-grade tape minimizes this difficulty, but the deposits cannot be totally avoided. Their results are loss of signal from the head, and accelerated wear of the tape itself as abrasion increases. It is usually necessary to carry out a preventive maintenance program at regular intervals; i.e., about 2 min per transport to clean the heads and tape guides.

MAGNETIC HEADS

Magnetic heads, of which there are two basic types, serve as a most important link in a magnetic recording system. They convert magnetic signals to electrical outputs. The first type, found in almost all recorders for audio and instrumentation work, generates a voltage proportional to the rate of change of magnetic flux bridging the air gap. This basic head design, Figure 5, records and reproduces both continuous and pulse signals. However, output voltage decreases when tape speed and recorded frequency are low, because of the lesser rate of flux change.

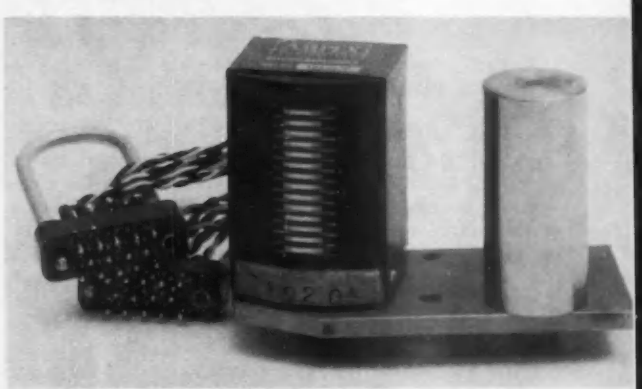


FIG. 5. A 14-track in-line head assures precise interchannel time relationships.

A second type of head, one responding to the magnitude of the flux level, overcomes this problem. This head reads signals from tape which is at or near standstill, thus producing signals even when tape is brought to a halt on a desired character frame. This prevents loss of information as the tape slows below what would be a minimum reading speed for the previously mentioned type. Another use of the magnitude-of-flux level head is in programming a conveyor system. Here an endless loop of magnetic tape simulates, on a scaled-down time basis, the actual conveyor. Low tape speed is related to the faster conveyor speed by the same time-scale factor, but the head still produces high output voltages at a good signal-to-noise ratio.

Heads are available in a variety of track configurations and widths. Standard analog heads read and write 14 tracks on 1-in. tape and seven tracks on ½-in. tape. Digital heads differ from analog heads in electrical characteristics and, more significantly, in geometry—the disposition of individual head gaps for each track. Analog heads require efficient shielding between tracks; hence it is customary to use two separate gap stacks

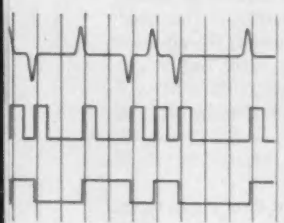


FIG. 6. Pulse amplifiers must be selected so that the recorded pips give the proper interpretation in accordance with the originally recorded signal.

for analog head assemblies containing more than four tracks per inch of tape width. For a seven-track head, tracks 1, 3, 5, and 7 are in one stack; 2, 4, and 6 are in another, with the even-numbered tracks interleaved between odd tracks. Tracks in digital heads are all in a single stack because shielding is not so important and because it is very important to minimize the possibility of reading a bit from another character. And interleaving is not needed because intertrack interference is not critical when signals are all recorded at tape-saturation level. (Newer-model heads read 16 tracks across a 1-in. tape.)

Two desirable characteristics of a head are high output voltage and long service life. High output makes reading easier, decreases gain requirements in the electronic system, and improves signal-to-noise ratio. Long life means reduced tape-mechanism maintenance and down time. For control operations, at least 5,000 hours of trouble-free use is desirable. High output requires thin magnetic sections at the air gap, but not so thin that at this point of wear useful life is reduced. A properly designed head, allowing only active parts of the magnetic circuit to contact the tape, will, in turn, reduce tape wear (removal of magnetic oxide particles).

ELECTRONICS FOR MAGNETIC PROGRAMMING

The electronics associated with the writing and reproducing of magnetic tape programs play a vital role in the overall success of an installation. For recording, electronic modules link input data to the tape, and for playback they link the stored program to the controlled system. Electronic functions must be carefully matched to control system requirements and the unique needs of the magnetic head-tape combination.

The specific electronic needs depend on the pulse or continuous form selected for the controlled system. A typical direct-record amplifier, for direct recording, contains a low-distortion high-stability amplifier with constant-current output. A potentiometer input control allows the amplifier to accept signals over a wide voltage level. The direct-reproduce amplifier utilizes a low-noise input, two feedback circuits, and plug-in equalization circuits.

Broad-band FM-type amplifiers, for FM signals, provide accurate reproduction of all signals, particularly those of low frequency. The FM record-amplifier contains dc-amplifier stages which modulate an oscillator whose output is applied to the recording heads. Plug-in elements accurately determine the FM carrier frequency. The FM reproduce-amplifier contains a six-stage limiter section, a phantastron pulse generator, and a plug-in output filter.

Pulse-code "pips" look like those shown at the top of Figure 6. Some applications call for amplification of pulses only during signal reproduction, so that the amplifier output is the same shape as the input pulse, but at a higher voltage level. In other applications, the pips can be reconstituted into pulses consistent with the originally recorded pulses. In this way, a typical pulse amplifier can produce a 5-microsec-duration pulse for each pip regardless of whether it is positive or negative on the tape. The interpretation of the middle pulse train in Figure 6 is that of restoring *NRZ-M* pulses; each positive or negative pip produces a **1**, and the absence of a pip produces a **0**.

For PDM signals, a pulse-duration-modulation record amplifier can take as inputs positive or negative pulses from 2 to 30 volts in amplitude. The pulses are amplified and limited, and then differentiated into short negative and positive pips. These, too, are amplified, and applied to the magnetic recording heads. The PDM reproduce amplifier reconstructs each pair of pips (defining a pulse) into the original pulse, as shown in the lower pulse train in Figure 6. The signals from the reproduce heads are amplified and limited. The zero-voltage crossover points of the pips trigger a pulse-reconstructing multivibrator or flip-flop circuit.

Fortunately, many of the necessary record and reproduce electronic functions are available, as already pointed out, as plug-in modules. Replacement of defective components is quick, with the result that the system is always in operation. Repair of the plug-in component can be made later by properly trained technicians at a location more amenable to troubleshooting than the location of the program unit.

REFERENCE

1. *MAGNETIC RECORDING TECHNIQUES*, W. Earl Stewart, McGraw-Hill Book Co., Inc., New York City, 1958.

Putting Logic to Work in Designing Distributed Program Control Systems

THE GIST: Several important engineering contributions now facilitate the design of sequence program control systems:

- *expansion of a line of versatile components, such as limit and proximity switches, stepping switches, electromechanical relays, meter-relays, and static switching devices*
- *formal logic methods, in which Boolean algebra plays a major role*

The need for sequential program control systems arises in many industries. Two applications, both involving functional design, will be described, one in the machine tool industry and using electromechanical relays, the other in the chemical industry and using static switching devices (Ref. 3).

For the most part, engineers designing today's program control systems use trial-and error methods in solving the logic. One reason for this is that other systems considerations demand far more engineering time than logic solution. But future program control systems may be so complex that time-consuming trial-and-error logic will no longer suffice; systems designed this way could very easily call for a redundancy of expensive equipment. Circuit simplification, a must for program control, justifies the use of Boolean algebra and its extensions.

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The design of sequential control systems using distributed programmers takes place in three major steps:

1. Stating the problem in a precise manner. This assures its complete understanding because it means that all input-output conditions have been considered (and may even result in an immediate partial solution). The problem statement takes the form of sequence charts and cause-and-effect truth tables. The sequence chart forces the designer to place his ideas in black and white, and thus helps him to specify only those inputs needed to obtain the desired outputs.

Also important is a tentative selection of appropriate sensing and input elements, since the physical operation of such devices must be consistent with the logical operations assigned to them. However, the final selection of equipment from among several alternates may rest upon later examination of the logic, including memory, needed to carry out the complete program sequence.

2. Examining the sequence chart. This step determines those portions of the system that are sequential (outputs depend on past history as well as present input) and thus require some memory, and those portions not involving memory that can be handled by combinational logic. This examination may be carried out in an orderly fashion by assigning variables and writing the outputs (either main system outputs or suboutputs within the system) in terms of all inputs that influence them.

If it is readily apparent from the sequence chart that an output is a function of its own state, then the output is fed back to be one of its controlling inputs. In complex arrangements, however, the extent of the memory will not be apparent and the Huffman-Mealy method (Refs. 1 and 2) can be employed to give an early indication of memory organization. This step will result in logical memory systems, but not necessarily the most efficient scheme from the viewpoint of the amount of physical equipment needed to fulfill the logic.

3. Simplifying the original combinational logic and memory scheme may be carried out by Boolean algebra manipulations, by map and chart techniques, and by numerical methods. Such simplifications mean considerable savings in expensive flip-flops, stepping and latching relays, and the like. An important part of this step is generating several equivalent logic circuits and choosing one that best fits the connectional and op-

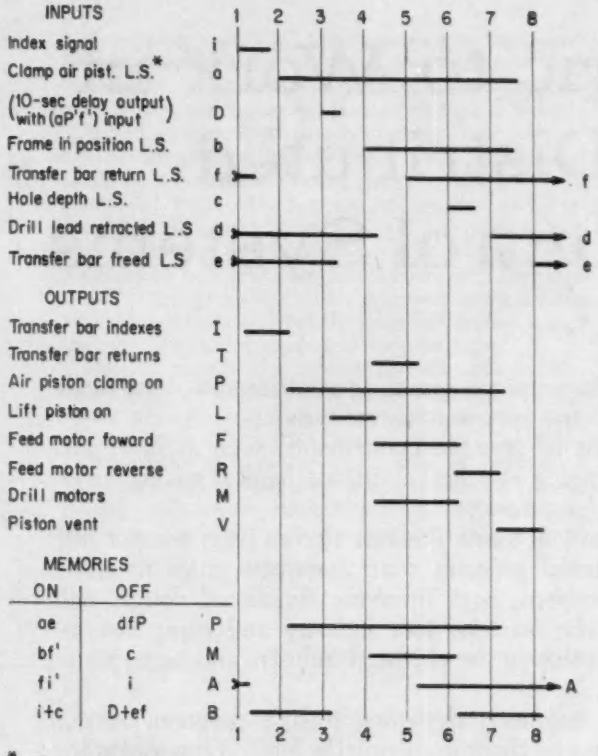


FIG. 1. Sequence chart for one station of a transfer machine.

SEQUENCE OF OPERATIONS FOR ONE STATION

1. *Transfer bar indexes, bringing a motor frame into this station.*
2. *Frame comes into place, tripping a limit switch actuating an air piston that clamps frame.*
3. *After a 10-sec delay a second piston lifts clamped frame from transfer bar, rotating it 90 deg.*
4. *Frame completes its rotation, tripping a limit switch to return transfer bar to its original position and starting a feed motor that moves drill head horizontally towards frame casting.*
5. *Transfer bar returns, tripping return limit switch, and stopping.*
6. *Four holes are drilled, tripping a limit switch at proper hole depth, stopping four drill motors, and reversing feed motor.*
7. *Drill head is retracted, tripping a limit switch to vent one end of double-acting air cylinder so that now frame is rotated 90 deg back to its original position and dropped onto transfer bar.*
8. *Frame comes into place on bar, tripping a limit switch in transfer-bar control circuit so that bar is now freed for next index.*

erational restrictions of the logical elements selected for the application.

Not to be overlooked in the circuit simplification effort is the effect on circuit maintenance. The disposition of relay coils and contacts may be completely correct, but if it is illogical to the maintenance man, he will have difficulty troubleshooting the circuit. Redundancy of equipment may at times be preferable to oversimplification.

MACHINE TOOL PROGRAM CONTROL

PROBLEM: Control the station of a transfer machine at which four holes are drilled simultaneously in the feet of an electric-motor frame. The distributed programmers are limit switches that open or close contacts by virtue of part position, and thus store position information about certain parts in the station. This information uniquely determines the position's particular state in its sequence of operations. The operations are initiated or halted by input signals or by a change of state of at least one of the limit switches. (A warning circuit, independent of sequence control, initiates an alarm when drills become dull.)

One way to state essential operations is in words, as shown in the table, but a better way is to use the sequence chart of the same cycle of events, Figure 1. This chart helps the engineer decide which distributed programmers to use, and helps him, too, in solving later on for circuit logic. At the top of the sequence chart are the inputs to the logic units, from an index signal, from a time delay, and from limit switches (L. S.). Note that each event is numbered in sequence from 1 through 8, and the start (ON) of each event marks the application of one of these signals. Note too, that the time these signals go OFF does not necessarily correspond to the exact end of the intervals. Thus, only those signals indicating when a limit switch was activated will be used as input signals; release signals, which cause a signal to change to its opposite state, will not be used.

The middle portion of Figure 1 shows the required outputs; these start and end some small time after the input state has changed. This delay helps the designer keep in mind the fact that logic units and relays have definite operate and release times, and also acts as a continual reminder of what is cause and what is effect.

Cause and effect truth tables

A warning circuit in the control system detects dull drills. Though independent of the rest of the system, it is a good circuit for describing how to use truth tables in the design of sequential program control systems. A meter-relay in each drill-motor circuit closes its contacts when current exceeds a preset value. Closed contacts from any relay trips the main control relay for the transfer bar drive and lights a warning lamp on the control panel. The warning light stays on until the worn drill is replaced; then the operator manually resets the warning circuit.

The closed contacts m_i on any one of the meter-relays initiates the warning signal m. Thus:

$$m = m_1 + m_2 + m_3 + m_4 \qquad (1)$$

where the + sign indicates the OR function, meaning that the four sets of contacts are in parallel. If r is

the reset signal and S is the warning signal, then a cause and effect truth table, Figure 2, may be used to design the simple memory circuit needed for this portion of the control system.

In Figure 2, each **0** indicates an open circuit and each **1** a closed circuit. The cause—the inputs m, r, and S^n—are at a time n, and the effect—the output S^{n+1}—is at later time $(n + 1)$, the time it takes the circuit to operate and come to its new condition. The superscripts on S indicate only the time of occurrence of each signal. Feeding back the output as one of its inputs is typical of memory circuits.

Since there are three input variables, each having two possible states, there are eight possible combinations of them ($2^3 = 8$) and thus eight possible conditions leading to an open or closed output. Each input combination is examined to see if an open or closed circuit is desired at the output. For example, the second row in Figure 2 states that a closed output is desired after m is not closed *AND* r is not closed *AND* S is closed. Symbolically, this statement is written as $m' \cdot r' \cdot S$, where the prime means the complement or *NOT* of that signal and the dot indicates *AND*. Further analysis shows there are five output conditions requiring an S output, each condition *OR* another *OR* another, etc., giving a closed circuit.

In switching algebra terms, the truth table can be written as:

$$S^{n+1} = [m'r'S + mr'S' + mr'S + mrS' + mrS]^n \quad (2)$$

This expression may be reduced by using some switching algebra (Boolean algebra) identities. First, the middle term is "added" in again, giving a sixth term, because an additional circuit, closed for $mr'S$, is the same as two circuits in parallel—each closed for the identical condition. Then factors are removed, which is equivalent to placing a single contact in series with two parallel circuits, each originally containing that contact. Thus:

$$S^{n+1} = [r'S(m' + m) + mr'(S' + S) + mr(S' + S)]^n \quad (3)$$

But functions

$$m' + m = S' + S = 1 \quad (4)$$

since normally open and normally closed contacts in parallel (on the same relay in steady-state) always give a closed circuit. And since a closed circuit in series with other contacts is equivalent to just the other contacts, Equation 3 reduces to:

$$S^{n+1} = [r'S + mr' + mr]^n = [r'S + m]^n \quad (5)$$

Equation 5 shows that the original truth table, Figure 2, specified a closed circuit warning signal *after* the following:

(NO reset AND a closed output circuit) OR (one or more motors drawing excessive current).

Figure 3 shows the switching circuit that performs the memory logic for this safety feature in the program controller. Here, the warning light is ON whenever relay S is energized. The relay coil should be viewed as S^{n+1} and the contact that latches it in as S^n.

Returning to the main sequence control problem, an examination of the inputs and outputs of the sequence chart (Figure 1) shows no obvious combinational relations between these inputs and outputs. Furthermore, the turning on of limit switches determines both the beginning and end of operation periods. Therefore, considerable memory must be involved in this program in addition to the information stored at any one instant by the states of the limit switches.

Since there are eight output states needed for the sequence of operations, one design approach would be to have eight separate memory units, one for each output (actually seven memories, because outputs F and M are the same). However, a reduction in the number of memory units would mean fewer relays and thus a more economical solution.

Ideally, three memories properly chosen could give eight states. But in this problem using three memories has an unpleasant feature: at least one of the outputs lasting more than one sequence interval (P or M), must be achieved by more than one combination of these three memories. This change to a new memory state to maintain a P or M output might momentarily result in the loss of an output signal. For instance, if the P-signal were momentarily lost, the motor frame might become unclamped and drop off completely or shift away from the drilling reference point. By using extra components (delays) and special relays, the three-memory system could probably be accomplished.

The solution chosen for this problem is to implement memory units that directly give outputs lasting more than one state of the sequence. This means separate memories of this type for outputs P and M. The other outputs last only one state of the sequence and so have changes at the beginning and end of their interval states.

More than one other memory must be used with the P and M memories because there are three states each for $P'M'$ and PM'. One other memory could uniquely define only two of the three states identical for P and M. But two additional memories with P

Inputs at time (n)			Outputs at time (n+1)
m	r	s	S
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

FIG. 2. Cause-effect truth table for designing a simple memory circuit.

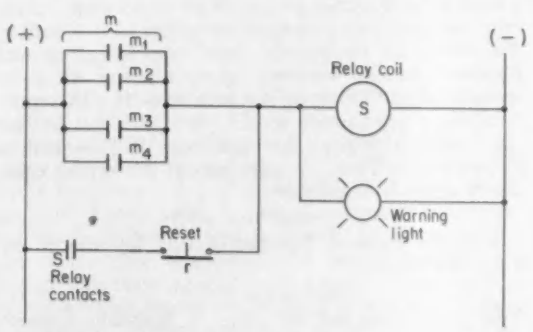


FIG. 3. Warning-signal memory circuit.

and M can easily uniquely define each of the eight states in the sequence. Two that accomplish this are shown as memory units A and B in Figure 1.

Designing memories for multiple-interval outputs

The output signal P, to drive the solenoid valve on the air-piston clamp, is chosen as the output from one of the four memory units. At instant 2 on the sequence chart (or shortly thereafter) P is to be switched *ON* and at instant 7 it is to be turned *OFF*. Note that input a comes on at instant 2, so it could possibly be used as an *ON* signal for P. But a should last as long or longer than P, so the *OFF* signal would have to turn the memory circuit off with the *ON* signal still present. Although such a circuit can be devised, it is more expedient to design a simpler memory. Returning to the input signals on the sequence chart, note that if the *ON* signal is chosen for ae (meaning the *ON* value only when both a *AND* e are present), then there is no problem: this signal

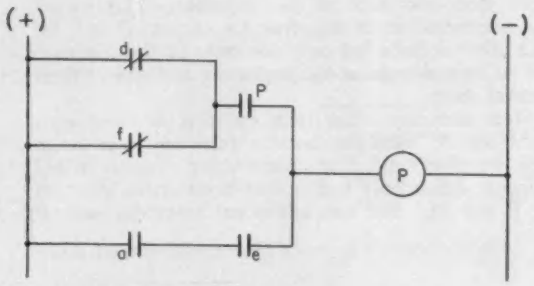


FIG. 4. P-memory circuit.

will go off shortly after instant 3—before the memory *OFF* signal is required.

The P-memory should be switched *OFF* at time 7, and since d comes on at this time it would appear, at first glance, that this signal could be used to initiate the *OFF* signal. But d lasts beyond time 2, when the *ON* signal should be applied. To prevent this, signal dfP could be used: because it would last only until P went to the *OFF* state some short time after instant 7. This "short time" assures completion of the change of state, and can be accomplished by a delay in the relay circuit.

The P-memory circuit can be developed from the preceding analysis via a cause-effect truth table. However, by substituting corresponding variables, Equation 5 developed for the warning signal memory can be used directly. In the warning signal, memory m corresponded to an *ON* signal and here ae is the *ON* signal. Similarly, r corresponds to dfP, the *OFF* signal. But the complement of r (that is, r′) or $(dfP)'$ is used in the equation. Thus, by substitution, the overall equation for the P-memory is:

$$P^{n+1} = [(dfP)'P + ae]^n \tag{6}$$

The first term of Equation 6 may be reduced by using the identity

$$(dfP)' = d' + f' + P' \tag{7}$$

Now, completing the first term of Equation 6 gives:

$$(d' + f' + P')P = (d' + f')P \tag{8}$$

since $P'P = 0$; that is, open and closed contacts in series gives an open circuit. Then Equation 6 can be reduced to:

$$P^{n+1} = [(d' + f')P + ae]^n \tag{9}$$

The P-memory circuit, Figure 4, can be drawn from inspection of Equation 9 (but note that closed contacts—shown as d and f—represent d' and f', while the other variables are represented as normally open contacts). By inspection, the first term of Equation 9 shows that d OR f are in parallel, and that these parallel contacts are in series (*AND*) with P. The second term a *AND* e means a circuit with contacts a and e in series. Since the two terms are connected by a + sign, their corresponding circuits are in parallel; and then, of course, the whole memory circuit is in series with the P relay coil.

The other three multiple-interval memories are derived in a manner similar to that used in finding the P and S memories. Memory A is chosen as shown at the bottom of the sequence chart, Figure 1, primarily because it is so easy to control. This selection forces the B-memory to have two *ON* and two *OFF* intervals, and thus somewhat more complex input signals. The form shown for the *OFF* terms at the bottom of Figure 1 are obtained by analysis of the sequence chart of signal combinations which appear when the memory is to be switched *OFF*. It is to be remembered that their complement form is used in equations. In switching algebra form ready for conversion to circuits, the three other memories are:

$$M^{n+1} \quad [c'M + bf']^n \tag{10}$$

$$A^{n+1} = [i'(A + f)]^n \tag{11}$$

$$B^{n+1} = [(e' + f')\,D'B + i + c]^n \tag{12}$$

Designing logic units for single-interval outputs

The sequence chart may be used to define the logic for those outputs lasting only one sequence interval. These outputs are a function of the four previously designed memory units, P, A, M, and B, which, in general, permit 16 possible states. However, since only eight sequences are needed in this problem, some reduction may be made in the switching circuits supplying the outputs.

The Veitch chart (Ref. 4; or Karnaugh map, Ref. 5) aids nicely in carrying out the reduction of a logic circuit to its simple form. The Veitch chart for this problem is shown in Figure 5. It contains the 16 possible combinations of the four inputs, P, A, M, and B. The two columns under P are the combinations containing P, and the other two columns are the combinations with P'. Likewise, the two rows even with M are for combinations containing M, while the top and bottom rows are for the M' combinations.

Thus, each square corresponds to a particular input combination. For example, the upper-right square corresponds to an input combination of $P'M'AB'$, or to the sequence interval $(8 - 1)$ where only memory A is *ON*. Since none of the outputs is to be *ON* in this interval, a **0** is placed in this square and the interval noted in the lower part of the square. In interval $(3 - 4)$ an output is desired only for L, so the lower left square $(PA'M'B')$ is **0** for all outputs except L, where it is **1**. The square for the other six intervals are filled in in a similar manner.

The remaining eight combinations (squares) not used by the four inputs from the memory circuits are

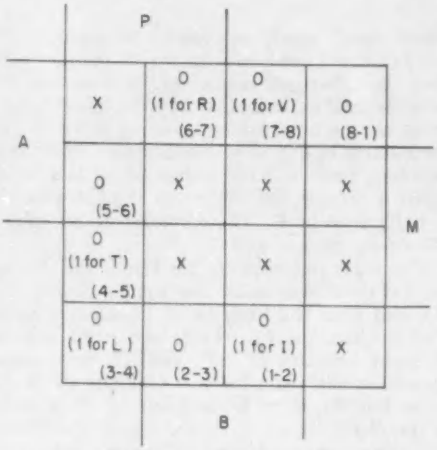


FIG. 5. Veitch chart for deriving output conditions.

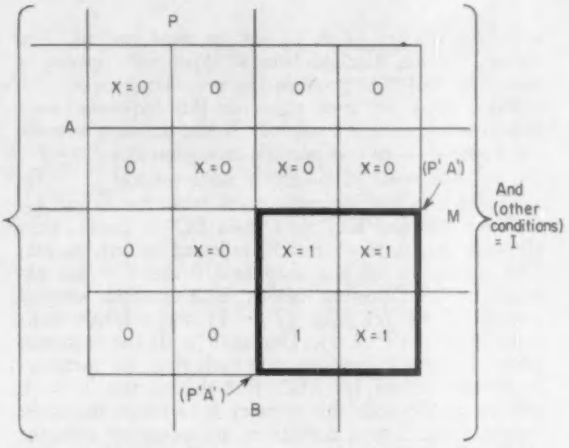


FIG. 6. Changing certain "don't care" conditions in Figure 5 to 1's in heavy box in this Veitch chart simplifies circuit for I output.

designated in the chart by **X**'s, which can be considered as "don't care" conditions since it makes no difference to overall logical operation whether a **0** or a **1** is assigned to them. However, by properly choosing a **1** or a **0** for an **X**, the output logic can be greatly simplified in many cases, with a corresponding reduction in needed equipment.

An example of logic circuit reduction is the Veitch chart for output *I*, Figure 6; it requires a **1** for the $(1-2)$ interval square. If all **X**'s are chosen as **0**, then *I* occurs for $P'A'M'B$; thus *I* is a function of four variables. Now, if a **1** is substituted for the **X** in the lower right square, the output becomes:

$$I = P'A'M'B + P'A'M'B' = P'A'M'(B+B') = P'A'M'$$

Thus, a **1** can be placed in a "don't care" square to introduce another output term containing the complement (*NOT*) of a variable, so that the variable (in this case $B + B'$) is eliminated as a necessary input for the desired output. Likewise, substituting **1**'s for the two remaining **X**'s in the lower right quadrant of Figure 6 simplifies the *I* output to $P'A'$. Thus, *I* is **1** for $P'A'$, regardless of the values of *M* or *B*. Now, glancing back at the sequence chart, it is seen that the only interval in which neither *P* nor *A* occurs is the interval $(1-2)$, and this verifies that only two signals are required to uniquely define this interval.

Signal *I* requires other conditions before it can be *ON*. Signal **e** must be present to insure the bar is freed for the next index, signal *S* must be *OFF* (indicating no dull drills), and the other stations in the transfer machine must all be freed to index. Hence, the index signal for the drilling operation is:

$$I = eS' \text{ (all other stations freed to index) } P'A' \qquad (13)$$

In a like manner, the Veitch chart of Figure 5 may be used to derive the other output conditions, simplifying the "don't care" conditions to the following:

$$T = MA' \qquad (14)$$

$$P = P; F = M \qquad (15)$$

$$L = A'M'B' \qquad (16)$$

$$R = PAB \qquad (17)$$

$$V = P'AB \qquad (18)$$

The relay switching circuit consists of two major sections, as shown in Figure 7. The memory and delay circuits consist of relay coils turned *ON* and *OFF* by appropriate combinations of their own contacts, and contacts from the limit switches disposed throughout the station. Then, appropriate combinations of (other) contacts on the memory relays provide the switching circuit outputs to operate the loads. No attempt has been made to reduce the number of contacts.

CONTROLLING TEMPERATURE SEQUENCE IN A BATCH REACTOR

PROBLEM: Design a program control system for maintaining a sequence of different temperatures in a reactor vessel. In this problem:

- *the program is sequenced as a function of time, rather than as part position*
- *static switching devices are used, rather than relays*

Four temperature values, each to be held one hour in the reactor vessel, are detected by four temperature controllers. For simplicity of description, the temperature controllers are thermostats, providing outputs h_1, h_2, h_3, and h_4 whenever the temperature is below that set for the particular thermostat.

A mechanical timer operates a switch which provides an output *T* for a short duration once each hour. The timer output triggers a sequential logic circuit so that each *h* is selected in time sequence to determine whether or not additional fuel is to be supplied to the reactor heating system. The signal for additional fuel is *H*. Such an arrangement will be recognized as a closed-loop temperature control system in which the set-point is changed every hour to a new temperature and maintained at that temperature during the interval.

One way to go about designing the sequential logic circuit is to use a stepping switch. Once each hour the timer would pulse the stepping switch to a new position and select the next thermostat in the sequence. The signal from the thermostat would be directed through the stepping switch to open or close a relay (or valve) controlling the fuel. However, for reasons of reliability (assumed because of severe environmental conditions and critical nature of the process) static

switching devices (Ref. 3) will be used instead. For similar reasons, the mechanical timer will operate a proximity switch to produce the sequencing pulse.

Since there are four states in this sequence, only two memory units are needed. If the memory outputs are E and G, then one possible arrangement is:

$$H = h_1E'G' + h_2EG' + h_3EG + h_4E'G \qquad (19)$$

Figure 8 is the sequence truth table for E and G. It shows that first $E'G' = 1$, then $EG' = 1$, etc., thus allowing only h_1 to control H, followed by only h_2, etc. The conditions for the outputs E^{n+1} and G^{n+1} are obtained by the following reasons: each one-hour interval consists of a short pulse ($T = 1$) and a longer non-pulse interval ($T = 0$). During $T = 1$, the sequence circuit initiates a memory state such that, for instance, an output occurs for EG'. But during the $T = 0$ portion of the hour the memory is to retain the same output state. These conditions are noted by asterisks in Figure 8. A similar situation exists for the other three pairs of rows; row 1 and row 8 are a pair. (Such action is analogous to a pulse moving a stepping switch to the next contact level with a mechanical detent keeping the contact in place until the advent of another pulse.)

Static switching memory elements require an *ON* signal to start the output and an *OFF* signal to turn off the output. The required *ON-OFF* signals are shown at the right in Figure 8, where E_N is the *ON* signal for E and E_F is the *OFF* signal. The **X**'s indicate "don't care" conditions since, for example, once E_N has become **1** and has turned E memory unit *ON*, then the *ON* signal may or may not remain *ON* until it is desired to have the unit switched *OFF*. This point can be observed by scanning down the E^{n+1} and E_N columns in Figure 8. Furthermore, since most static switching units will not switch off as long as the *ON* signal is present, the table also specifies that when E_F is **1**, E_N is to be **0**. These considerations apply to the G-memory unit as well.

The logic and circuitry for the E and G memories can be developed from the Veitch charts, Figure 9, obtained from the truth table, Figure 8. Consider the Veitch chart for E_N. There are eight combinations of input variables E^n, G^n, and T^n, and hence eight squares in the chart for E_N. Column E_N in Figure 8 shows four **0**'s, three **X**'s and one **1**. These are entered in the chart, Figure 9, in the square corresponding to the appropriate condition of the input variables. Thus, the E-memory output is **1** for $E'G'T$ (or **001**). As shown, the memory is a function of three variables, but the circuit can be simplified (and still maintain the same logic) by introducing a **1** in place of an **X**. This is shown by the enclosed inner rectangle in Figure 9. The output is now $E'G'T + EG'T = (E' + E)G'T = G'T$. Hence, memory output E_N is no longer dependent on the state of input E^n. The same approach is taken for the reduction of the logic for E_F, G_N, and G_F, as shown in Figure 9.

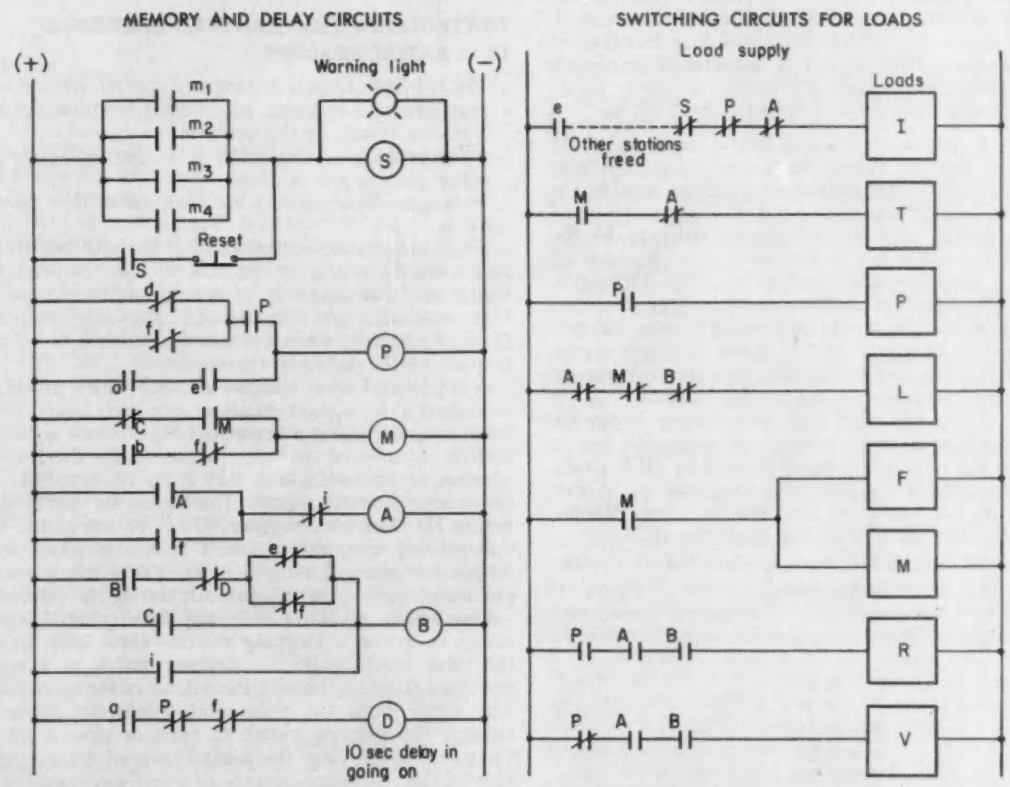


FIG. 7. Complete memory and load switching circuits for one station of a transfer machine.

Inputs at time (n)			Outputs at time (n+1)		ON-OFF signals for inputs of memory units E and G			
E^n	G^n	T^n	E^{n+1}	G^{n+1}	E_N	E_F	G_N	G_F
0	0	0	0	0	0	X	0	X
*0	0	1	1	0	1	0	0	X
*1	0	0	1	0	X	0	0	X
1	0	1	1	1	X	0	1	0
1	1	0	1	1	X	0	X	0
1	1	1	0	1	0	1	X	0
0	1	0	0	1	0	X	X	0
0	1	1	0	0	0	X	0	1

FIG. 8. Sequence truth table specifying E and G memories.

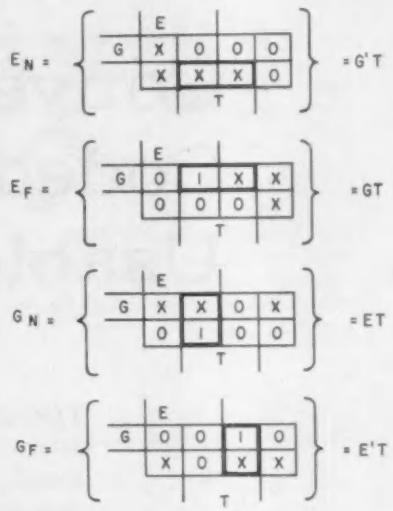


FIG. 9. Map reduction of ON and OFF signals for E and G memories.

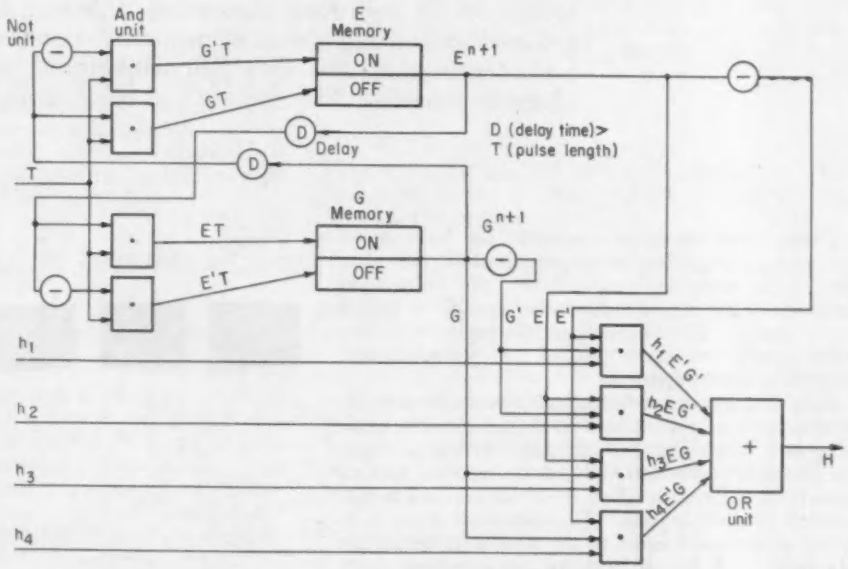


FIG. 10. Complete static switching circuit for controlling temperature sequence program of a reactor vessel.

The logic and memory circuits obtained from the preceding analysis are shown at the top of the complete circuit diagram, Figure 10, for the sequence control system. Note that delays, greater than the duration of pulse *T*, are introduced at the memory outputs to insure that only the single desired change takes place for each application of *T*. Connected in this way, the upper circuit produces the unambiguous combinations of *E* and *G* (and their complements), to pass the thermostat *ON* signals in sequence through their corresponding *AND* units and thus produce the heat *ON* signal, *H*, to increase vessel temperature.

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4. *LOGICAL DESIGN OF DIGITAL COMPUTERS*, M. Phister, John Wiley & Sons, Inc., 1958.
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Converting Pulse and Coded Data into Usable Output Signals

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Dept. of Mechanical Engineering
Case Institute of Technology

THE GIST: In many recorded-information program controllers (such as punched-tape or -card and some magnetic-tape equipment) the stored command intelligence is in the form of pulse or coded data. This data must be manipulated to suit the internal requirements of the programmer and then converted to a usable output signal that will force the controlled variable to follow the recorded command. To design the internal programmer networks, a control engineer must be familiar with the relative merits of the various language forms, and with the techniques for code-form conversion, code-to-code conversion, scalar and arithmetic manipulation of numerical control data, and the methods of converting this data into proportional analog quantities for closed-loop control. This article covers these items.

Programmed numerical controllers use both digital and analog computing techniques, because one gives them high resolution and accuracy, the other wide bandwidth. Besides, the controlled variable is almost always analog. The following article applies these so-called hybrid techniques (Ref. 1) to pulse-data and coded-data control systems.

Pulse-data systems are sometimes referred to as incremental numerical systems and are characterized by measuring and controlling through pulse counting, where the quantum (numerical value of the smallest unit of measure in the system—Ref. 2) of information is represented by a single pulse. The excursions of the controlled variables are equal to the time integrals of the data pulses and the end-point of one excursion serves as the zero reference for the following excursion.

In contrast, coded-data or absolute numerical systems are characterized by measuring and controlling through numerically coded intelligence, where the absolute value of the controlled variable is represented by a singular pattern or numerical code.

Figures 1 and 2 show the two basic control systems. Contemporary systems in which both a variable and its derivative are to be controlled are usually of the pulse-data type; bandwidth limitations restrict an arithmetic unit. Systems requiring only point-to-point control of the variable can use either pulse or coded data. The factors governing this choice are not of immediate interest, and only those elements that are shaded in Figures 1 and 2 will be treated here.

THE TWO TYPES OF CONTROL SYSTEMS

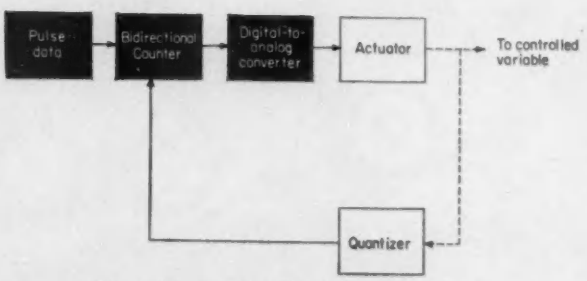


FIG. 1. Elements of a pulse-data control system.

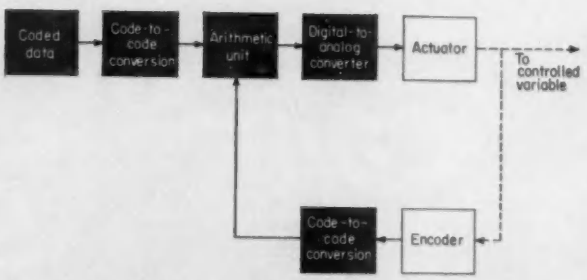


FIG. 2. Elements of a coded-data control system.

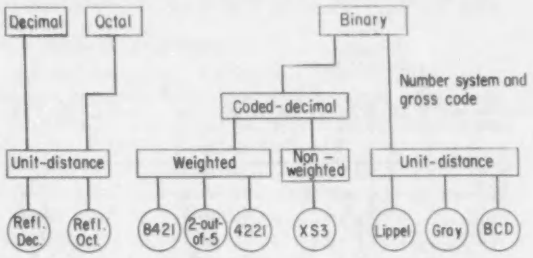


FIG. 3. Organization of common codes.

NUMERICAL CODES

A numerical code is a system of characters and rules for representing information (Ref. 3), with the choice of code form depending on the application. For example, in a hybrid control system it is quite common to use different code representations of the intelligence between the system and its parasitic elements: a decimal input code used because of operator familiarity might be converted to a conventional binary form to simplify the arithmetic unit logic, and compared with reflected binary intelligence generated in the encoder in the feedback path.

An examination of numerical codes means first an examination of the number systems within which the codes are expressed. If N is defined as a decimal number, A as an admissible mark in the particular number system, r as the number system's radix [the number (decimal) of admissible marks within the system], and n as the position number of the mark (rightmost mark in N has the position number zero), then

$$N = \sum_{-m}^{n} A_n r^n$$

To illustrate:

$$11.1]_{\text{decimal}} = 1 \times 10^1 + 1 \times 10^0 + 1 \times 10^{-1}$$
$$11.1]_{\text{octal}} = 1 \times 8^1 + 1 \times 8^0 + 1 \times 8^{-1} = 9.125]_{\text{decimal}}$$
$$11.1]_{\text{binary}} = 1 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} = 3.5]_{\text{decimal}}$$

Now examine the organization chart of common codes shown in Figure 3, bearing in mind that only those codes are to be considered that are readily adaptable to a hybrid numerical control system. This excludes all codes not derived from the binary number system, since numerical data is normally manipulated with two-state dynamic elements. (It is important to note here that several successful numerical systems use simple decimal data manipulation. This discussion is limited to systems synthesized from two-state logic, since these systems have higher levels of manipulative potential.)

The binary code

The binary code is a weighted, analytic code and is undoubtedly the most popular code used in hybrid numerical control. It expresses control information in terms of two admissible marks, 0 and 1. The binary code can be written in the general form for a weighted number code as

$$N = A_n w_n + A_{n-1} w_{n-1} + \cdots A_i w_i \cdots A_{-m} w_{-m}$$

where A_i is the coefficient of the ith position and w_i is the weight assigned to the ith position. In the conventional binary code: $w_0 = 1$, $w_1 = 2$, $w_2 = 4$, $w_3 = 8$, and $w_n = 2^n$; while $A = 0$ or 1.

The conventional binary code is most ideally suited to mechanical manipulation. Its only significant disadvantages involve visual recognition and electronic translation into decimal notation.

Coded-Decimal Codes

The 8421 code, sometimes called binary-coded decimal, uses the first four positions in the binary system and the first 10 binary numbers. It is a weighted, analytic code with the admissible marks 0 and 1. The general form is

$$N = \sum_{0}^{i} 10^i \sum_{n=0}^{3} A_{n_i} 2^{n_i}$$

where i is the position number of the decade and n_i is the position number of the mark A_{n_i} within the decade.

This code's principal advantage is the ease of visual recognition and electronic translation, its principal limitation the complexity of arithmetic operations, which often means conversion to another form prior to extensive arithmetic manipulation. Also, timing problems are introduced in the "carry" operation. Parallel preset becomes difficult because feedback loops must be present within a decade to permit multiple decade operation. Finally, the code uses equipment inefficiently: four dynamic elements represent only ten decimal digits, whereas the equipment can represent 16 decimal numbers.

The XS3 code

This is a nonweighted code and is simply the 8421 code with binary 3 (0011) added to each decimal decade. The general form is

$$N = \sum_{0}^{i} 10^i \left[\left(\sum_{0}^{3} A_{n_i} 2^{n_i} \right) + \sum_{0}^{1} 2^m \right]$$

where i is the position number of the decade and n_i is the position number of the mark within the decade.

This code provides a simplified "carry" process since the nine's complement are complementary within each decimal decade, and is readily adapted to arithmetic operations. However, easy visual recognition is hampered by the XS3 appendage, and inefficiency of hardware utilization is equivalent to that of the 8421 binary-coded decimal code.

The biquinary code

Sometimes known as the 2-out-of-5 code, this is a nonanalytic, weighted code expressing control intelligence in terms of seven binary marks per decade. Reading from left to right, the weighted values of the mark positions are 5, 0, 4, 3, 2, 1, 0. The general form is

$$N = \sum_{0}^{i} 10^i \left[A_{n_i}(5) + A_{n_i-1}(0) + A_{n_i-2}(4) + A_{n_i-3}(3) + A_{n_i-4}(2) + A_{n_i-5}(1) + A_{n_i-6}(0) \right]$$

where i is the position number of the decade and n_i is the position number of the mark A_{n_i} within the decade.

Checking ease is the important advantage of this code; in any decimal number representation the code contains two 1's and five 0's. Arithmetic manipulation is extremely difficult, however. This code is

widely used in computer design (IBM 650) because of its checking feature. Hardware is used inefficiently: seven binary elements are required to represent 10 decimal digits.

*The 2*421 code*

This is a weighted code expressing control intelligence in terms of four binary marks. Reading from left to right, the weighted values within a decade are 2*, 4, 2, 1. The nine's complements are complementary within each decimal decade and the code, like XS3, is readily adaptable to arithmetic manipulation. Visual interpretation is difficult and hardware utilization efficiency is comparable to that of the 8421 code.

Unit-Distance Codes

Here, code words representing consecutive numbers differ in one digit position only, and in that position the digits differ by one only. This can be contrasted with the conventional binary code in which one or all digits can change in a unit transition.

The reflected-binary code

Also known as the cyclic-binary or Gray code (after its inventor—Ref. 4), this is the most common unit-distance code. It can be interpreted columnwise by the relation

$$= \sum_{i=0}^{n} 2^i$$

where n is the position number of a binary 1. The sign of the term is positive for all odd numbers of binary 1's and negative for all even numbers of binary 1's, numbered to the right from the most significant digit. The Gray code is therefore a nonanalytic, nonweighted code; i.e., the sign is not fixed term by term. Because of its nonanalytic nature, it is not directly adaptable to arithmetic manipulation; however, its simply defined structure permits ready translation into conventional binary. Hybrid programmed systems using coded data often employ an encoder using this code in the information feedback loop.

Other unit-distance codes of more than academic interest are the Lippel codes (Ref. 5), the reflected-decimal codes (Ref. 6), and the unit-distance binary-coded-decimal codes (Ref. 7).

Each code discussed above has certain qualities that might warrant its adoption in a numerical control system. These qualities have been referenced to the code's adaptability to self-checking, visual recognition, mechanized translation, arithmetic manipulation, efficient logical hardware utilization, as well as to certain physical properties well suited to analog-to-digital conversion devices. At present the conventional binary and binary-coded-decimal codes find about equal favor in hybrid programmed numerical systems.

CODE MANIPULATIONS

Once a suitable code has been selected, one or more operations directly related to the coded data must be performed within the system. These operations are:

1. code-form conversion, converting between serial and parallel forms or to some intermediate combination.

2. code-to-code conversion, converting decimal to binary, Gray to binary, etc.

NETWORKS FOR CODE-FORM CONVERSION

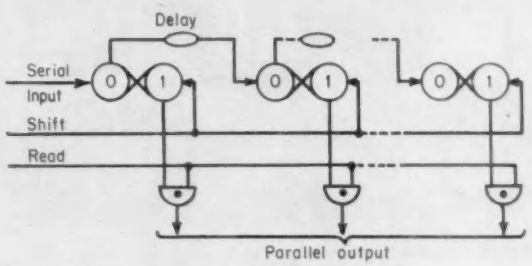


FIG. 4. Serial-binary-to-parallel-binary conversion.

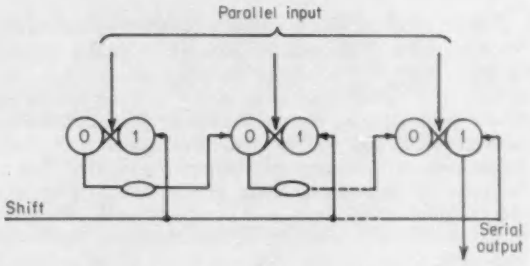


FIG. 5. Parallel-binary-to-serial-binary conversion.

3. arithmetic manipulation, comparing the data with other (numerical feedback) data, or using it to control other numerical circuitry such as scalers, frequency dividers, etc.

4. digital-to-analog conversion, converting numerical data into analog form to permit physical control of a process.

Code-Form Conversion

Binary-coded serial data can be readily converted to parallel data by means of the gated-output shift register shown in Figure 4. Here serial data is applied to the set input of the first flip-flop which transfers its contents to the second flip-flop through the reset action of the shift pulse. (Transfer is initiated by a $1 \rightarrow 0$ binary transition.) The first flip-flop is then ready to accept the next serial digit. The transfer between stages is delayed sufficiently to permit the reset to be completed. At the end of the serial input sequence a readout pulse opens the appropriate gates, thereby generating serially equivalent data in parallel form.

Parallel input data is converted to serial output data in a somewhat complementary manner. Here the flip-flops are preset in parallel and their contents progressively shifted through the register, Figure 5. The overflow at the downstream end of the register is the serial equivalent of the register's parallel input.

Code-to-Code Conversion

Code-to-code conversions are performed to permit each portion of a control system to use data in its most convenient code. For example, a designer might encode feedback loop data in cyclic binary and convert this cyclic binary to conventional binary for arithmetic manipulation. Each situation requires a code-to-code

conversion within the hybrid numerical control system.

Decimal-to-XS3 conversion

When converting a decimal code to any coded-decimal system a diode matrix is arranged to give the coded-decimal equivalent of each digit in the decimal number. Figure 6 shows a matrix for converting decimal to XS3. If the selected decimal digit is six, note that the plus voltage is grounded through resistors in columns 4-OFF, 3-ON, 2-ON, and 1-OFF. Output signals are therefore present on 4-ON, 3-OFF, 2-OFF, and 1-ON, producing a code 1001 which is the XS3 equivalent of decimal six.

Binary-to-decimal conversion

To convert a whole binary number into its decimal equivalent, the binary number is first divided by 1010 (the binary equivalent of decimal 10) and the remainders are converted to decimal digits by means of a binary-to-decimal diode matrix. For example, to convert the binary number 10000000 to decimal:

$$\frac{10000000}{1010} = 1100 \text{ with } 1000 \text{ remainder}$$

$$\frac{1100}{1010} = 1 \text{ with } 0010 \text{ remainder}$$

$$\frac{1}{1010} = 0 \text{ with } 0001 \text{ remainder}$$

The remainders are then arranged in inverse order (0001, 0010, 1000) and each is converted to decimal notation by means of the diode matrix shown in Figure 7. The decimal equivalent of the three remainders is seen to be 128. The above mentioned divisions can be readily mechanized by standard arithmetic logic (Refs. 8 and 9).

Decimal-to-binary conversion

First determine the binary equivalent of each decimal digit by means of a diode matrix and then multiply each binary number thus obtained by 1010 a number of times corresponding to the order of the original decimal digit. The resulting numbers are then added to produce the binary equivalent of the original whole decimal number. Figure 8 shows the diode matrix for performing the initial conversion prior to multiplication by 1010. Binary multiplication procedures are covered in References 8 and 9.

Reflected-binary-to-binary conversion

In converting reflected binary to conventional binary, 1) the most significant 1 digit in reflected binary is also a 1 in conventional binary; 2) successive reflected

NETWORKS FOR CODE-TO-CODE CONVERSION

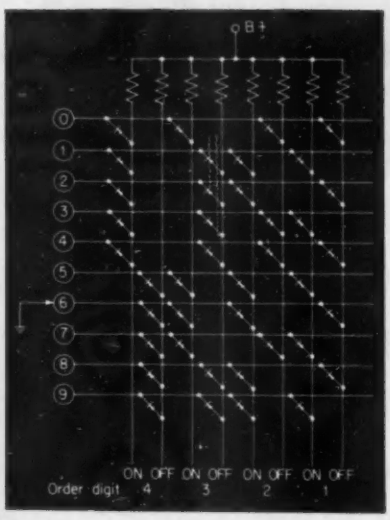


FIG. 6. Diode matrix for decimal-to-XS3 code conversion.

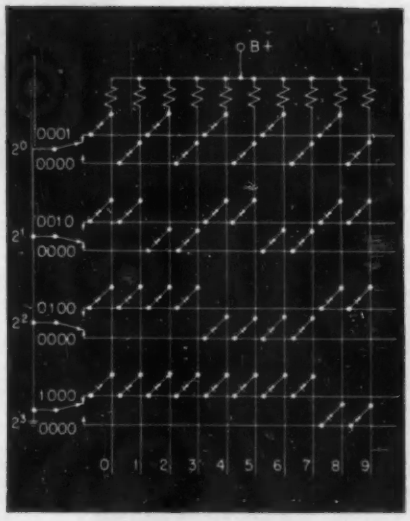


FIG. 7. Diode matrix for binary-to-decimal code conversion.

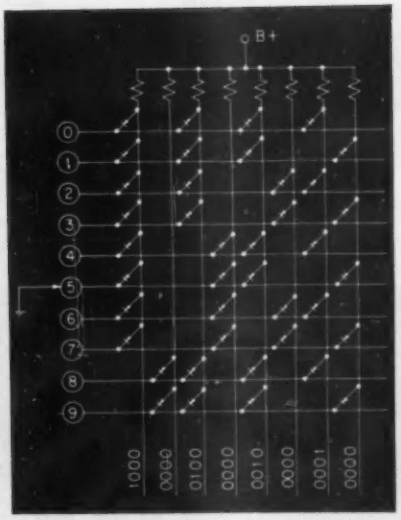


FIG. 8. Diode matrix for decimal-to-binary code conversion.

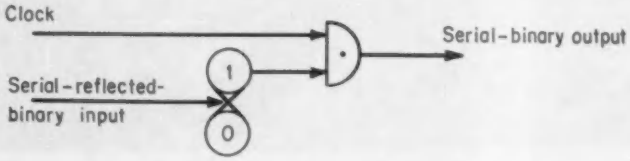


FIG. 9. Serial-reflected-binary-to-serial-binary code converter.

binary digits then are complemented as many times as there are 1's preceding them. For example,

$$110010]_{\text{reflected}} = 100011]_{\text{binary}}$$

Susskind describes an extremely simple circuit for performing this conversion, Figure 9 (Ref. 10). Here the reflected binary is expressed as a serial pulse train, leading with the most significant reflected digit. Each pulse representing a 1 in the reflected binary complements a flip-flop, so that each binary digit is represented by the state of the flip-flop. The latter, in turn, opens an AND gate when it is in the 1 state, passing clock pulses (with the same period as the serial data but slightly lagging). Each passed pulse represents a binary 1 in the translated binary number.

Many other code-conversion schemes are described in References 10 and 11.

DATA MANIPULATION

In the actual process end of a hybrid programming system data manipulation consists merely of arithmetic or scalar comparison of numerical command and feedback data.

Pulse-Data Comparison

In pulse-data systems the manipulation is merely a scalar comparison between the time integral of the command pulses and the time integral of the feedback pulses generated by a quantizer. Figure 10 shows a typical scalar comparator (Ref. 12). This bidirectional binary counter has the ability to accept forward and backward pulse-data command pulses and backward and forward quantized pulses. Pulses are added if the transfer connection between flip-flops is from the 0

NETWORKS FOR DATA COMPARISON

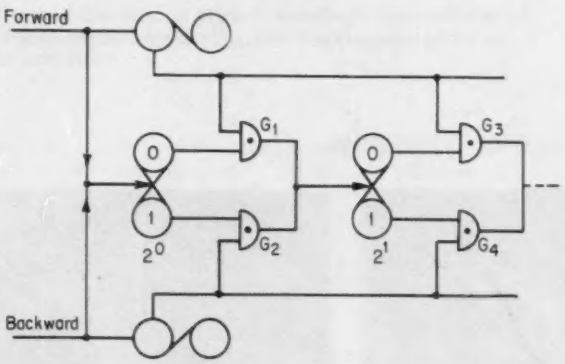


FIG. 10. Bidirectional binary counter.

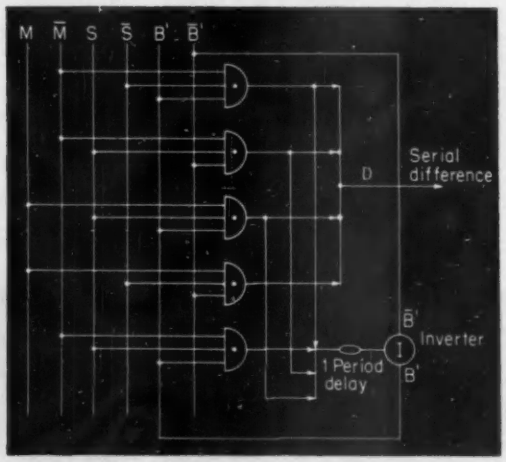


FIG. 12. Serial binary subtractor.

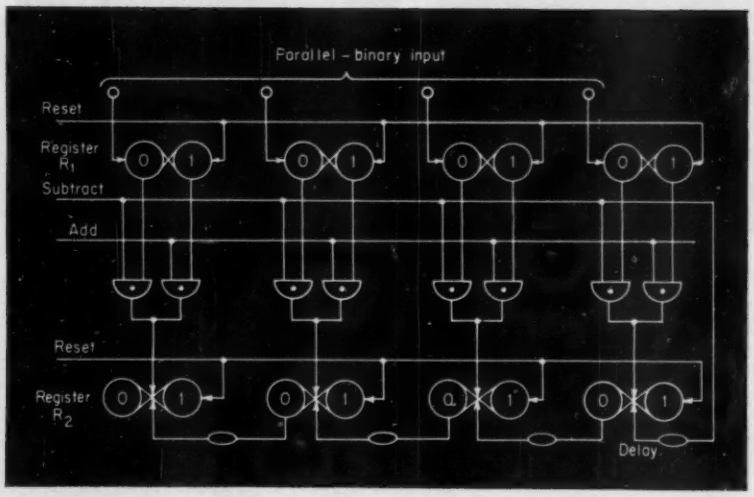


FIG. 11. Parallel binary adder-subtractor.

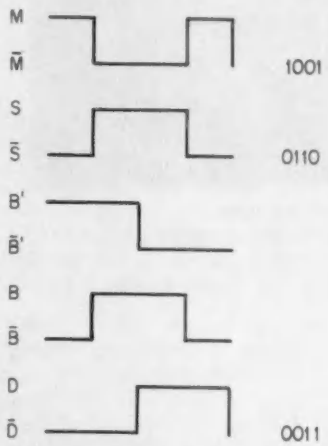


FIG. 13. Timing diagram for serial binary subtractor, subtracting 0110 from 1001.

side of the preceding flip-flop. This means a transfer is generated by a $1 \rightarrow 0$ transition. Conversely, pulses are subtracted if the connection is from the 1 side. Forward pulses establish the zero-side connection by opening AND gates G_1, G_3, etc. Backward pulses establish the one-side connection by opening gates G_2, G_4, etc. The time duration of gate openings is fixed by the total transfer time of the counter and is physically controlled by the monostable elements' time constants. Note that the quantizer must be connected to the counter in a degenerative manner to mix the forward command pulses with the backward quantized pulses.

Coded-Data Comparison

Comparing coded command data and encoded feedback data in coded-data systems is an actual arithmetic process that can be performed in either a parallel or serial manner. Figures 11 (Refs. 13) and 12 show typical logical circuits for performing this operation.

Parallel binary subtraction

The logic of Figure 11 is the result of adding the complement of the subtrahend to the minuend plus an "add one" operation on the sum. For example,

$9_{\text{decimal}} = 1001_{\text{binary}}$ 1001

$6_{\text{decimal}} = 0110_{\text{binary}}$ 1001 (complement of 0110)

add $\overline{10010}$

add 1 $\downarrow$ 1

$+0011$

The extra 1 is interpreted as plus.

To carry out this operation the circuit performs as follows: 1) reset commands set registers R_1 and R_2 to zero ($R_1 = 0000$, $R_2 = 0000$); 2) the minuend is set in parallel into register R_1 ($R_1 = 1001$, $R_2 = 0000$); 3) the add command transfers the contents of R_1 into R_2 and R_1 is reset ($R_1 = 0000$, $R_2 = 1001$); 4) the subtrahend is set in parallel into register R_1 ($R_1 = 0110$, $R_2 = 1001$); 5) the complement of the subtrahend transfers into register R_2 ($R_1 = 1001$, $R_2 = 0000$); 6) all flip-flops in R_2 generate a delayed transfer to the next most significant digit when changing state from 1 to 0 ($R_2 = 0010$); 7) the delayed subtract command to the 2^0 flip-flop produces the "add one" operation ($R_2 = 0011$). This circuit can be easily modified to handle negative differences.

Serial binary subtraction

The logic circuit is shown in Figure 12 (Ref. 14). Here M is the incoming binary digit of the minuend, S the incoming binary digit of the subtrahend, B' the borrow digit determined in the preceding subtraction, D the serial difference digit, and B the serial borrow. Denoting $M = 0$ by $\overline{M}$, $S = 0$ by $\overline{S}$, $B' = 0$ by $\overline{B'}$, $M = 1$ by M, $S = 1$ by S, and $B' = 1$ by B', the logical expressions describing the operation of the subtractor of Figure 12 are as follows:

$$D = (\overline{M} \cdot \overline{S} \cdot B') + (\overline{M} \cdot S \cdot \overline{B'}) + (M \cdot S \cdot B') + (M \cdot \overline{S} \cdot \overline{B'})$$

$$B = (\overline{M} \cdot \overline{S} \cdot B) + (\overline{M} \cdot S \cdot \overline{B'}) + (\overline{M} \cdot S \cdot B') + (M \cdot S \cdot B')$$

The timing diagram in Figure 13 shows the operation of the circuit subtracting 0110 from 1001.

This discussion has been confined to operations within the binary code; similar arithmetic data manipulation can be performed with most of the other codes mentioned earlier.

DIGITAL-TO-ANALOG CONVERSION

The previous comparison circuits yielded numerical quantities representing the instantaneous error between the command and the controlled variable. This error must now be converted into a proportional analog quantity to control the system's actuator so that the controlled variable will follow the command data. Only a few of the better-known conversion techniques will be covered here. Reference 10 is recommended for a thorough treatment of the subject.

Parallel-binary-to-analog-voltage conversion

Figure 14 shows a ladder network using constant current sources for converting a parallel binary number into a proportional analog voltage. The circuit has been used extensively in numerical control systems and is fully described in References 10, 12, and 15. The converter uses only two values of precision resistors and the current sources feed equal impedances, permitting sources of equal magnitude.

The output voltage is a linear function of the decoded binary number

$(d_n d_{n-1} d_{n-2} \cdots d_0)$

and can be expressed by

$$e_0 = \frac{2}{3} \frac{RI}{2^n} (d_n 2^n + d_{n-1} 2^{n-1} + d_{n-2} 2^{n-2} \cdots d_1 2 + d_0)$$

where d assumes the value 0 or 1.

Parallel-8421-to-analog-voltage conversion

Figure 15 shows a schematic; detailed circuitry is given in Reference 16. This circuit can be readily adapted to electronic actuation by equal and constant-current sources. In practical applications where an electron tube is used as the current source, its plate resistor must be made large compared to the sum of the precision resistors in the decoding chain if all sources are to be of identical design. Two or three decades is the practical limit because of resistor tolerances. The output voltage is a linear function of the decoded binary-coded decimal number, as follows:

$$e_0 = IR(d_3 2^3 + d_2 2^2 + d_1 2^1 + d_0 2^0) + 10\,IR(d_7 2^3 + d_6 2^2 + d_5 2^1 + d_4 2^0)$$

where d assumes the value 0 or 1.

Parallel-reflected-binary-to-voltage conversion

Figure 16 shows a circuit for converting reflected binary into a dc voltage; originally presented in a significant paper by Foss (Ref. 11). Note that the value of every resistor in the net is $2^n R$, where n is the code digit position number and R is the value of the resistor in the zero-digit position. Resistor switching provides a constant impedance load to the reference voltage E_0. The describing equation is

$$e_0 = \frac{E_0}{2^{n+1} - 1} N$$

where n is the position number of the largest decodable digit and N is the decimal value of the decoded reflected binary number.

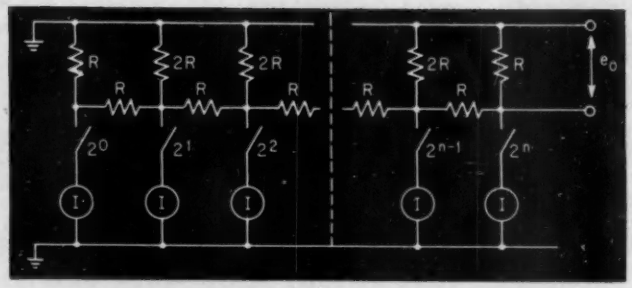


FIG. 14. *Parallel-binary-to-analog-voltage converter.*

NETWORKS FOR DIGITAL-TO-ANALOG CONVERSION

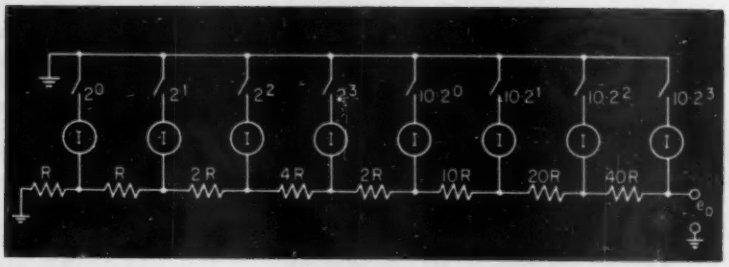


FIG. 15.
Parallel-binary-coded decimal-to-analog-voltage converter.

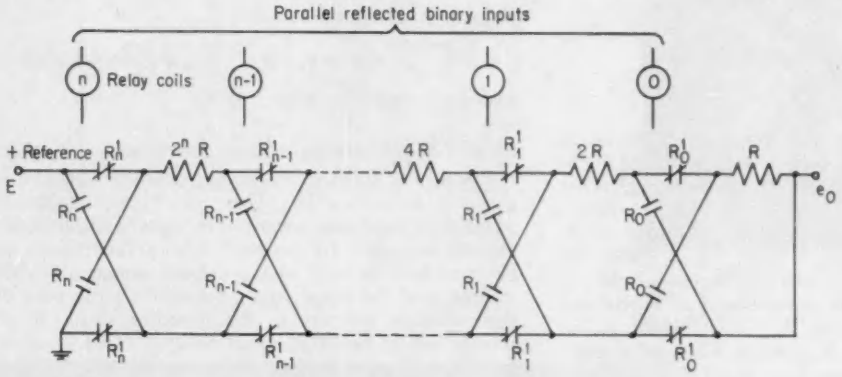


FIG. 16.
Parallel-reflected-binary-to-analog-voltage relay converter.

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Interpolation—A Link Between Programmed Points and Smooth Curves

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THE GIST: Program control, using punched tape or cards, offers a good deal of system flexibility. A problem rises, however, when the controlled system requires a smooth continuous input. The problem—how to provide this continuous input from a programmer that stores data in the form of discrete points. The trick, of course, is to interpolate between these points. Either linear or higher-order interpolation can be provided by mechanization of some interpolating function that passes through several of the programmed points. Both digital and analog approaches to this problem are common.

The role of interpolation in control systems is not unlike that in most other applications, being principally the generation of a smooth curve from a limited number of discrete points. In control applications these discrete points might define the contour to be followed by a cutting tool, the trajectory of a guided missile or the set-point of a pneumatic controller in a pilot plant operation. Where the desired curve is truly three-dimensional, one variable may be considered a function of two others, in which case bivariate interpolation is appropriate. In most systems developed to date, however, the three-dimensional effect is obtained in two steps, by successive applications of interpolating functions of one variable. These functions may take many forms; most useful so far are those of the polynominal type:

$$y = f(x) = a_0 + a_1x + a_2x^2 + \ldots a_nx^n \qquad (1)$$

The coefficients a_k are usually determined by requiring that the nth degree polynominal pass through $n + 1$ given points. In some cases it may be desirable to replace some of the $n + 1$ points by other conditions which might, for example, require continuity of slope between the polynominals for successive sets of points. As yet, little advantage has been taken of such possibilities.

The concept that one variable is a function of another (or of two others), though useful in a great many systems, cannot be applied universally. Consider, for example, the machine-control problem of milling an irregular closed contour in the x-y plane. Over portions of the contour where variation of y with respect to x is relatively mild, y may be regarded as a function of x. However, for other portions of the contour, y is more appropriately regarded as the independent variable. Otherwise, double-valued functions are required. Unless coordinates are shifted, simple polynominal interpolation with Equation 1 is inadequate, and a more general form, $F(x, y) = 0$ (2) is desirable.

Although most of the techniques and equipment described on the following pages originated in the field of machine-tool control, their application is by no means limited to this area.

LINEAR ANALOG INTERPOLATION

The effect of a linear, or first-degree-polynominal, interpolation with respect to time is obtained simply by maintaining uniform velocity between two points. If the same time base is used for two or more motions, the interpolation is linear with respect to each motion.

Overall accuracy of such an interpolation depends on the accuracy with which velocities are maintained and the accuracy with which end-points are established. For short distances conventional velocity-servo techniques, using precision tachometers for feedback, provide good accuracy. In one instance, a numerically-controlled lathe has been reported capable of cutting tapers to within 0.1 deg. In this system, a punched-tape program supplies end-points and feed rates in coded form. Precision voltage dividers generate voltage commands, which are balanced by potentiometers in the case of end points, and tachometers in the case of feed rates (Refs. 1, 2).

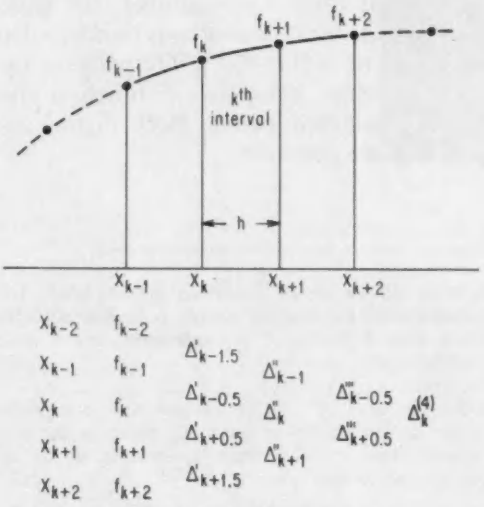
HIGHER-DEGREE ANALOG INTERPOLATION

Higher-degree interpolation may be performed by well-known analog-computer techniques. In one approach, a tapped transformer arrangement supplies a number of intermediate points lying on a parabola passing through any three given points. A linear

bridging between the intermediate points then gives the gross effect of a second-degree interpolation (Ref. 3).

An example of a cubic or third-degree interpolator is that developed at the NACA Lewis Flight Propulsion Laboratory (Refs. 4, 5). This device uses three ball-and-disc integrators to generate a third-degree polynominal, which passes through four evenly-spaced data points as indicated in Figure 1. The section between the two central points serves for active control: as the interpolator moves on to the next interval, the polynominal is redetermined to include the next data point and omit the most remote. The interpolating formula employed over the k^{th} interval is

$$f(x) = f_k + \Delta'_{k+0.5}\,\theta + \tfrac{1}{2}\Delta''_k\,\theta(\theta-1) + \tfrac{1}{6}\Delta'''_{k+0.5}\,\theta(\theta+1)(\theta-1) \qquad (3)$$



X_{k-2}	f_{k-2}				
		$\Delta'_{k-1.5}$			
X_{k-1}	f_{k-1}		Δ''_{k-1}		
		$\Delta'_{k-0.5}$		$\Delta'''_{k-0.5}$	$\Delta^{(4)}_k$
X_k	f_k		Δ''_k		
		$\Delta'_{k+0.5}$		$\Delta'''_{k+0.5}$	
X_{k+1}	f_{k+1}		Δ''_{k+1}		
		$\Delta'_{k+1.5}$			
X_{k+2}	f_{k+2}				

FIG. 1. A third-degree polynomial set up for interpolating in the kth interval. Polynomial passes through four surrounding data points.

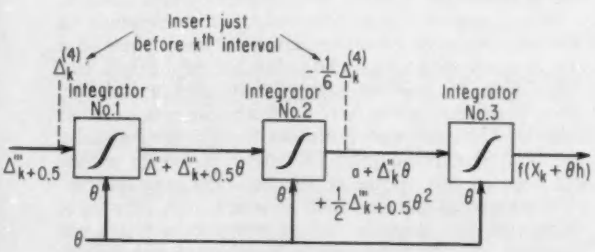


FIG. 2. Three integrators arranged to produce a third-degree polynomial.

or $$f(x) = f_k + (\Delta'_{k+0.5} - \tfrac{1}{2}\Delta''_k - \tfrac{1}{6}\Delta'''_{k+0.5})\theta + \tfrac{1}{2}\Delta''_k\,\theta^2 + \tfrac{1}{6}\Delta'''_{k+0.5}\,\theta^3 \qquad (4)$$

where $\Delta'_{k+0.5} = f_{k+1} - f_k$ and $\Delta^m_j = \Delta^{m-1}_{j+0.5} - \Delta^{(m-1)}_{j-0.5}$

The independent variable x is equal to $x_k + \theta h$ where h is the interpolation interval and θ varies from 0 to 1 across the interval. The first, second, and third derivatives of $f(x)$ are

$$\frac{df}{d\theta} = (\Delta'_{k+0.5} - \tfrac{1}{2}\Delta''_k - \tfrac{1}{6}\Delta'''_{k+0.5}) + \Delta''_k\,\theta + \tfrac{1}{2}\Delta'''_{k+0.5}\,\theta^2 \qquad (5)$$

$$\frac{d^2f}{d\theta^2} = \Delta''_k + \Delta'''_{k+0.5}\,\theta \qquad (6)$$

$$\frac{d^3f}{d\theta^3} = \Delta'''_{k+0.5} \qquad (7)$$

The required polynominal $f(x_k + \theta h)$ results from three successive integrations with respect to θ, starting with $\Delta'''_{k+0.5}$. Figure 2 shows three integrators arranged to accomplish this.

If the integrators are correctly set at the start, a simple adjustment of the integrands of the first and third integrators is sufficient in proceeding from one interval to the next. Immediately before the k^{th} interval, $\Delta^{(4)}_k$ should be added to the first integrand and $-\frac{1}{6}\Delta^{(4)}_k$ to the third (assuming θ starts over at 0 for each interval). Ideally, then, only the fourth difference associated with each interval need be supplied to the interpolator. In practice, it was found desirable to supply the actual data points also. Any discrepancies detected were corrected over the next interval by an adjustment of the third integrand, thereby preventing the gradual accumulation of errors due to inaccuracies in the computing elements.

In another version of the cubic interpolator, one of the three integrations is obtained by means of a precision potentiometer (Ref. 6). The potentiometer bridges two voltages, preset in accordance with appropriate differences, and its shaft rotates with the independent variable. In effect, it interpolates linearly between the two voltages. In this system, the nature of the input data is somewhat different, but in both systems information is supplied by punched cards, one card per interval. An experimental model of the second system is reportedly able to produce a voltage corresponding to Equation 4, with a maximum deviation of 0.15 percent. Overall system accuracy is within 0.1 percent of the total excursion of the dependent variable.

A third example of a cubic analog interpolator mechanizes the Gregory-Newton interpolation formula and permits operation of a cam-gear shaper from a printed-circuit-card program (Ref. 7). It consists of two sections: a linear generator for handling the linear terms in the equation, and a δ generator that provides the curvature correction. The linear generator contains a single precision potentiometer centrally located in a string of series resistors. Relays across each of these resistors permit the potentiometer to be located electrically at any potential between 101 volts and ground. Potentiometer position represents the programmed point. By itself, then, the potentiometer-resistor-relay combination forms a linear interpolator.

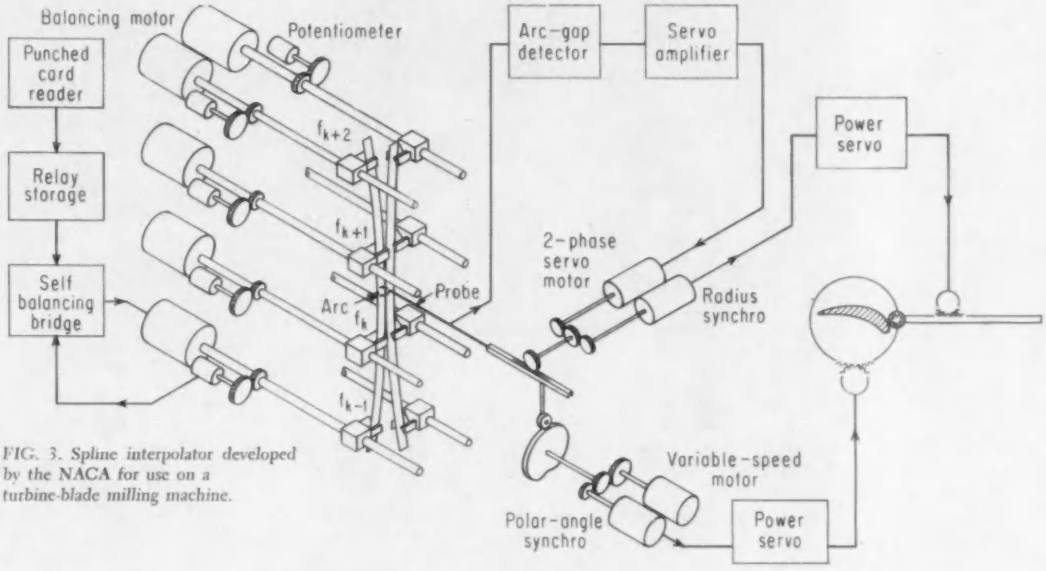


FIG. 3. Spline interpolator developed by the NACA for use on a turbine-blade milling machine.

The δ generator, which provides the curvature correction, is basically a self-balancing bridge. It is designed to generate a signal corressponding to the difference between a third-degree polynomial and the first-degree polynomial produced by the linear interpolator. Three legs of the bridge consist of elements representing higher-order difference combinations and up to second-degree terms in the independent variable. The bridge is balanced by an auxiliary servo that drives a potentiometer acting as the fourth leg. The other legs are set-up in such a way that, when the bridge is balanced, the fourth leg turns out to be the desired curvature correction.

SPLINE INTERPOLATION

The curve assumed by a flexible metal strip or spline, constrained to pass through a number of specified data points, is the basis for another NACA interpolator (Ref. 5). The complete system, illustrated in Figure 3, consists of two identical splines, each positioned by knife edges at four equally-spaced points along its length in accordance with specified values of the dependent variable. These values are read from punched cards as four three-decimal-digit numbers and converted to voltages by means of precision voltage-divider networks. A servomotor and leadscrew drives each knife edge until an associated potentiometer balances the divider voltages. Only the center interval of each spline is used for control purposes. These sections are traced by a probe connected to a high voltage source to cause continuous arcing to the spline. Servoing the spline in accordance with the voltage drop across the arc maintains a constant probe-to-spline distance.

Two splines are included in the system to permit continuous operation. One spline is traced while the other is being positioned. In Figure 3, for example, the probe is driven up the left spline by a cam as the knife edges supporting the right spline are set up for the next interval. When the boundary is reached the probe shifts to the right spline and moves downward in synchronism with the independent variable.

DIGITAL INTERPOLATION

The interpolation function can also be performed on a discrete or digital basis. A classic example is the numerically-controlled milling machine developed at MIT (Ref. 8). The metal cutting element of the system, an adaptation of a conventional vertical-spindle milling machine, provides tool motion along three mutually perpendicular axes.

In operation, a punched tape continuously supplies blocks of elementary instructions to the machine-control unit or director. Each instruction block specifies: (1) the incremental motion required along each axis, and (2) the time interval in which all motions are to be executed. The nature of the control system is such as to spread all motions evenly over the allotted time interval. This produces a straight-line path between two points in space or, in effect, a linear interpolation between these points.

Heart of the control system is the pulse distributor, which may be referred to more generally as a binary operational multiplier. This unit produces three pulse trains, each containing a number of pulses proportional to the motion required by a given instruction. Each pulse in the MIT system calls for an incremental motion of 0.0005 in.

The pulse distributor, or interpolator, consists basically of a 10-stage binary counter, and is shown schematically in Figure 4. Each of these 10 stages produces two groups of pulses, called "carry" pulses and "noncarry" pulses. The carry pulses occur when the flip-flop changes from ONE state to the ZERO state, and serve to trigger the next stage in the counter. The interspersed noncarry pulses, representing transitions from the ZERO to the ONE state, are segregated as potential command pulses.

Since each successive counter-stage divides the input pulse rate by two, the 10th stage produces a carry pulse for every $2^{10} = 1{,}024$ input pulse. If the input rate is 512 pulses per sec, such an end-carry pulse is produced every 2 sec. During each 2-sec interval the first stage emits 512 noncarry pulses, the second stage

256, and so on down to the 10th stage, which emits 1. Any number of pulses Δx (up to 1,023) may be obtained during a 2-sec interval by gathering noncarry pulses from appropriate stages. As may be demonstrated, pulses should be taken from every stage, k, for which the coefficient of 2^{10-k} in the binary expression for Δx is 1. Thus the number Δx in parallel binary form may be used to control gates directly to select exactly Δx pulses during the interval. The fact that no two noncarry pulses occur at the same time allows a simple mixing of the pulses from each stage, without overlap.

Two additional sets of gates, Δy and Δz, operating on the same noncarry lines, permit the generation of three separate pulse trains for controlling the three axes of the machine. The action of the circuitry is such that if the input pulse rate is uniform, each of the three resulting pulse rates will be nearly uniform over the entire 2-sec interval. Even if the input rate is not uniform, the output pulse trains will always bear approximately the correct ratios to each other. The result, then, is a set of command pulse trains for the three machine motions describing essentially a straight line in space.

The quantities Δx, Δy, and Δz referred to above represent the number of 0.0005-in. units of motion required

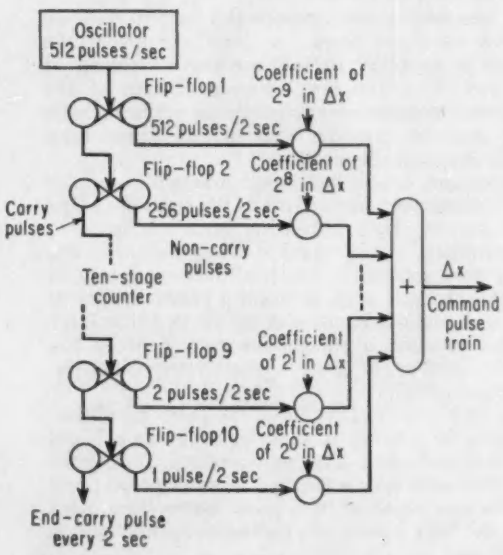


FIG. 4. Pulse distributor or binary operational multiplier used in the MIT machine.

along their respective axes in one time interval. With an input pulse rate of 512 pulses per sec and a 10-stage counter as described above, the time interval is 2 sec. In the MIT machine, different time intervals are provided for by the inclusion of seven additional counter stages, any number of which may be interposed between the pulse source and the first stage shown in Figure 4. The addition of one stage, for example, extends the time interval to 4 sec; all seven stages would extend it to 256 sec. Also, as more stages are added, the command numbers Δx, Δy, and Δz may contain more digits. At the maximum distributor length of 17 stages, a stroke of $2^{17}-1 = 131{,}071$ units may be called for, corresponding to a distance of 65.5355 in.

The particular time interval desired is specified by the punched control tape. Any required feed rate may be closely approximated with the discrete set of time intervals available by subdividing the straight-line section into a number of shorter sections. Suppose a distance of 12 in. is to be traversed at a rate of 6 in. per min. Total time required is 2 min or 120 sec. This period may be obtained by using one standard interval of 64 sec, one of 32 sec, one of 16 sec, and one of 8 sec (the total being 120 sec). The total distance is divided proportionally: 6.4, 3.2, 1.6, and 0.8 in. for the respective intervals. Feed rate may be varied also by changing the pulse rate into the distributor. The MIT machine provides for continuous manual adjustment over the range from 60 to 120 percent of the nominal 512 pulses per sec.

Control information, including Δx, Δy, and Δz, is read one block at a time into relay registers in the machine-control unit. Two complete registers are provided to make possible continuous machine operation from one interval to the next without pause at the boundary. While one register actively controls the machine, the second register assimilates information for the next interval. When the boundary between intervals is reached (and signified by an end-carry pulse from the distributor), control is shifted to the newly-filled register.

The numerical information requires only three channels of a seven-channel tape. The remaining four channels are coded to permit redundancy checking of the tape punching and reading operations. In each row of hole positions, a single error can be detected and corrected, and a double error detected. Additional checking circuits monitor the operation of most other major portions of the system.

Essentially the same interpolation technique has been applied to the control of a three-dimensional cam-milling machine, Fig. 5 (Ref. 9). The machine is of lathe-like configuration, in that the workpiece rotates about an axis as the cutter moves radially and axially with respect to it. The axial motion of the cutter is geared to the work spindle, tending to produce a helical path over the surface of the work, as in cutting a screw thread. The cross-slide motion is servoed to vary the radius of the helix continuously in accordance with information supplied by a punched tape. Although the resulting contour is three-dimensional, by virtue of the fixed axial feed only two motions need to be program controlled the angle along the helix and the radius of the helix.

The machine uses a binary operational multiplier similar in logical function to that of the MIT machine. In the cam machine, however, input pulses for the multiplier are obtained from a quantizer coupled to the work spindle rather than from an oscillator. Output pulses act as command pulses for the servo, varying the radial position of the tool. In effect, then, the radius of the part is controlled as a function of the angle of rotation. In the same terms, the MIT machine may be considered to control three linear motions as a function of time, since there the multiplier input is a pulse source having time as its base.

Analogously, operation of the cam machine is divided into *angular* intervals instead of *time* intervals. The

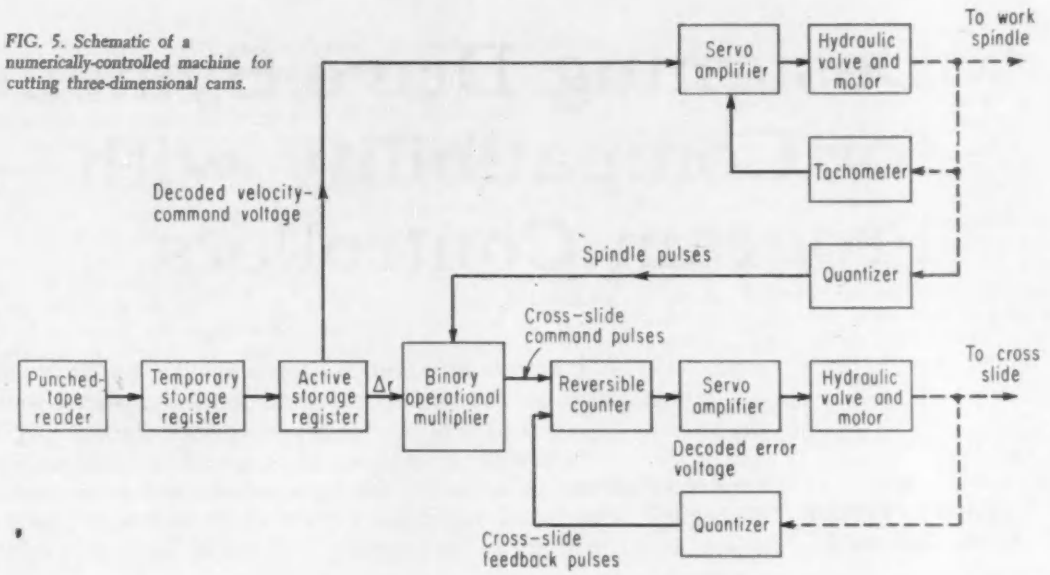


FIG. 5. Schematic of a numerically-controlled machine for cutting three-dimensional cams.

spindle quantizer is geared to generate 256 pulses for each 5 deg of cam rotation. An eight-stage multiplier, therefore, produces an end-carry pulse every 5 deg; a k-stage multiplier, every 5 $(2)^{8-k}$ deg. Length of the multiplier, hence size of the angular interval, is controlled by the input tape. In the original machine, intervals of 5, 10, 20, and 80 deg are available. Multiplier gates are set in accordance with the number of command pulses to be produced in an angular interval, each such pulse calling for a radial tool motion of 0.0002 in. If, for example, a change in radius of 0.03 in. is required in 5 deg, 150 pulses must be selected from the 256 produced by the spindle quantizer as the cam rotates through the 5 deg. This selection is achieved if the multiplier gates are opened for those stages whose corresponding digits in the binary representation of 150 (10010110) are 1. Distribution of the 150 pulses is approximately uniform over the 5-deg interval, and consequently, the overall effect is a linear interpolation of radius as a function of angle. Because of the cylindrical coordinate system, the actual curve produced is an arc of an Archimedean spiral.

Later versions of this control equipment have been designed for a wide range of machine types. The interpolating element of these systems is still based on the binary operational multiplier. However, it makes use of magnetic-core storage elements and serial computing techniques, for a significant reduction in the number of components required (Ref. 10).

Other examples of digital interpolation can be found in machine-control systems in which a magnetic-tape link is interposed between the machine proper and the special-purpose computer, or "director", that provides the interpolation. In one of these systems, the operational multiplier operates in a coded decimal language, rather than in binary (Ref. 11). In another, the operational multiplier idea is extended considerably with the addition of counters and other logical circuits in such a way as to permit the generation of circles, parabolas, ellipses, and hyperbolas (Ref. 12).

As mentioned earlier most of the equipment discussed here was developed primarily for use with numerical machine-tool systems. Its application in other fields, however, should not be overlooked. Simulation, aircraft and missile control, and even certain areas of process control can be made more flexible by the careful application of digital programming techniques coupled with some form of interpolation. Certainly the future will see more information published on such applications.

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Designing Drive Systems for Compatibility with Program Controllers

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THE GIST: The advent of the unit program controller, and the numerical type in particular, has pushed industrial control engineers toward the systems approach. These new high-performance controls put the rest of the system to some severe tests, often revealing inadequacies in heretofore satisfactory actuators, mechanical links, and even machines themselves. This article highlights the causes of inaccuracy, poor response and instability in programmed equipment, and gives capsule design data on

- *actuators*
- *stabilizing methods*
- *mechanical links*
- *machine factors*

In several respects at least, the designer of industrial equipment must regard a human operator as the ideal controller. An operator has limited response, so it is not difficult to design a machine to keep up with him; his capability for accuracy is also easily matched in terms of machinery; and he is craftsman enough sometimes to compensate for design inadequacies—to get more out of a machine than was really built into it. The same is certainly not true of automatic controls which are extremely fast and accurate, and tend to reveal rather than to compensate for equipment faults. As a result, the control engineer can never guarantee the overall performance of a system unless he is willing (or allowed) to look beyond the control cabinet.

Experience gained from the application of numerical controls to existing equipment (retrofit) and to equipment of conventional design has shown that the obstacles to good overall performance occur in the two major areas beyond the control itself: the drive and the machine. The control engineer has a definite responsibility for preventing or dealing with faults in the drive section, since it is within the servo loop. And he should be knowledgeable enough at least to make recommendations for the design of machines that will be compatible with automatic controls.

TROUBLE SOURCES

Compliance, or the tendency of mechanical parts to distort under load, can be a source of trouble in the power drive equipment. It is difficult for the servo designer to stabilize a system that has an unexpected spring somewhere between the drive unit and the machine structure. This spring may be traced to a cast member of insufficient rigidity to support the end thrust of a positioning lead screw; an undersized pinion shaft in a rack and pinion drive; gear tooth deflections; or improper bearing supports. Such compliances may not cause measurement errors directly because despite them, the servos may become deactivated when the proper position has been reached. This is especially true when some type of direct-measurement transducer is used for feedback. Instead, the errors may occur after a stop relay has been energized and as the bent casting or strained pinion drive relaxes, causing slight additional movement of the controlled member.

To prevent this type of compliance error, the mechanical parts in the drive series should be designed to withstand the required forces without undue deflection. This is not always a simple case of making parts heavier and larger. A better approach may be to relocate ribs in a casting, or to reshape the casting to place the support material in the right places. Relaxation errors can be prevented by arranging systems to relieve the driving forces after the programmed command has been carried out.

It is axiomatic, of course, that compliance can exist only because there is resistance to the movement of the mechanical elements being controlled. The compliance problem, therefore, becomes proportionately less if inertia, metal cutting loads and friction forces, which are the principal causes of such resistance, are minimized.

The effects of backlash, which is a second major cause of difficulty, are frequently confused with those of compliance. Backlash also causes motion of the power drive equipment without corresponding motion of the driven element. Its effects on the stability of a control system are unmistakable, however: backlash

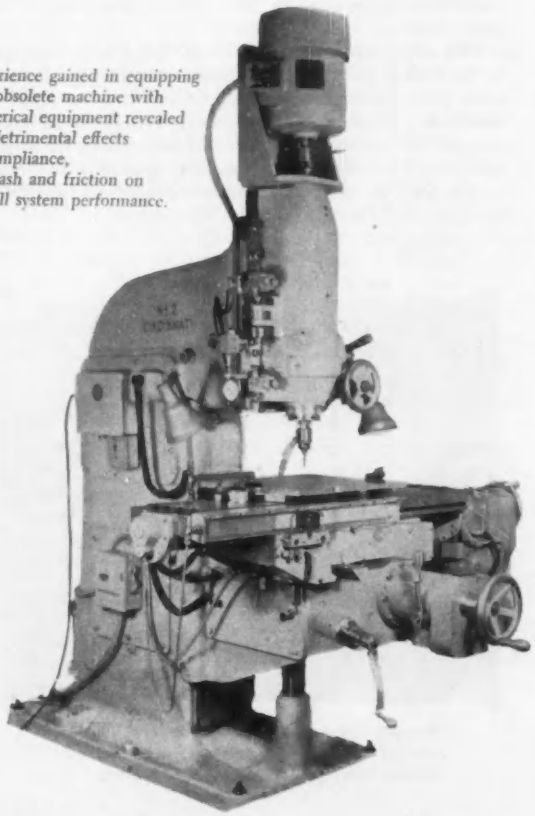
allows the drive motor to move freely through the backlash region, while compliance produces some restraining force and resonance. A servo system can be stabilized to a repeatability of $\frac{1}{3}$ to $\frac{1}{10}$ of the amount of backlash referred to the moving element of the machine. However, this repeatability is not attainable unless there is some friction, and unless the servo is permitted to overshoot a few times during positioning.

Backlash in other portions of the controlled equipment are beyond the control engineer's province, but are still a frequent source of trouble. It is obvious that play in a spindle, for example, must be eliminated if good accuracy and repeatability are to be achieved. Side play in ways or other guide surfaces is lost motion akin to backlash, and can result in the controlled element moving at right angles to the programmed path and perhaps even rotating.

Friction accounts for some system errors—principally because it is the source for most of the forces that cause deflections due to compliance. The machine tool itself rather than the drive contributes the major friction loads. The principal drive elements, such as actuators and feedback transducers, are normally low-friction devices. But the leadscrew, if one is used in the drive, can be a prime friction source. The ball bearing leadscrew has been a helpful solution to this problem.

From the standpoint of machine design, the lessening of friction has been a main objective for some time. The control engineer finds, therefore, that most modern equipment incorporates some form of antifriction way surface. This measure plus pressure lubrication, proper design of the way surfaces, skilled manufacture of surfaces, and the use of special lubricants reduce friction forces sufficiently for the bulk of applications. Where deflections due to friction are intolerable and the highest accuracy is desired, it may be advisable to use roller ways. Such ways consist of flat surfaces on the two relatively movable parts, with a number of cylindrical rollers distributed between them.

Inertia is another factor that may limit control effectiveness. High mechanical inertia is usually undesirable because it implies resistance to movement and, hence, can contribute to compliance deflections. Also, inertia hinders response and stopping accuracy. The control engineer can help minimize inertia by proper choice of actuator, certain types of which are characteristically high-inertia devices. And, when he is brought in on the project early enough, he should be quick to recommend inertia-reducing techniques throughout.



Experience gained in equipping this obsolete machine with numerical equipment revealed the detrimental effects of compliance, backlash and friction on overall system performance.

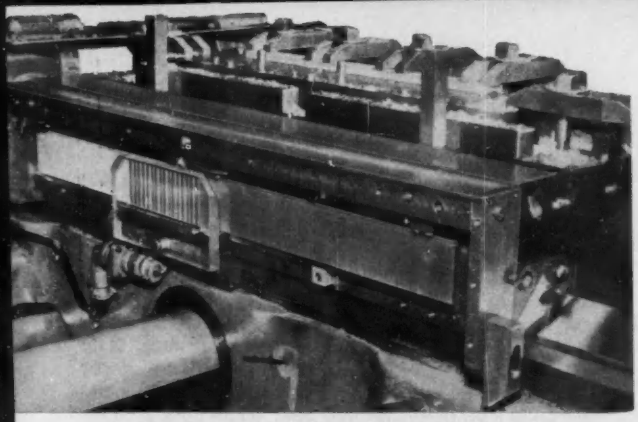
ACTUATOR SELECTION

As stated, the control engineer has a clear-cut responsibility in the design of the drive section—the link between the control and the machine. Here, his main responsibility may pertain to the selection of an actuator that will enable the machine to follow control commands with fast response and high accuracy.

The control engineer bases his choice of power actuator for a programmed system on the combination of the machine loads and the response desired. The machine loads, including stiction, friction, inertia and, in some cases, cutting forces, are largely fixed by the time the control engineer enters the picture. But he may have the opportunity to influence the response requirement since this has a great bearing on the entire control-system design as well as on the accuracies obtainable. A demand for extremely fast response usually means high-capacity power actuators plus added refinements in the control circuitry to provide stability and accuracy. In programmed positioning systems, for example, it is frequently desirable to incorporate electrical clutch-controlled gear shifts in the positioning drives to obtain the combined advantages of speed of positioning over appreciable distances and high precision at the final positioning point. Similar gear changes and very slow final approach speeds are used for discontinuous relay-type servos to minimize any variations in the final coast.

The electric motor is the actuator most used with recorded-information controls because of the unlimited variety available to meet operating requirements and because of the ease with which electric motors may be wired into the control loop. One handicap is that conventional types of motors add considerably to system inertia. In fact, the motor inertia is very often the major part of the overall inertia. It is important, therefore, to calculate horsepower requirements meticulously since overpowering can be detrimental.

Electric motor drives usually include some form of step-down gearing between the motor and the machine. Care must be taken to minimize gear backlash since it has a critical effect on the stability of the servo in high-accuracy systems. Similarly, the gear boxes and other mechanical portions of the drive system must be designed for minimum deflection. A combination of "springiness" of the drive members and friction of the driven element results in an instability of the positioning system that may be nearly impossible to compensate for. The simple experiment of dragging a small weight with a highly flexible spring will illus-



Linear Inductosyn installed on machine tool. Even such direct-measurement data elements cannot completely isolate defects in the drives and machine sections of programmed systems.

trate the "jumpy" and unpredictable mode of motion that may be expected.

Standard polyphase ac motors are commonly selected for programmed positioning functions. Multispeed gear boxes with electric clutches provide whatever pattern of speeds is specified for the application, such as one beginning with rapid traverse to near set-point, followed by a slow-speed zone, and then by a creep stage to the desired final position. Stopping in this case can be accomplished simply by de-energizing the motor. When the final approach speed is low enough and the machine is properly designed, the final coast to a stop will be reproducible enough for programming even precision jig-boring operations.

Because of their high torque to inertia ratio, two-phase motors have been chosen for some positioning functions calling for fast response. These motors have a high-slip characteristic and a torque output proportional to the product of the voltages on the two phases. A conventional method of control uses a magnetic amplifier supplying the control power to one phase of the motor while the other phase is excited directly from the power lines. In general, these motors are inefficient and are not widely recommended for integral-horsepower drives.

The most frequently used prime mover in programmed positioning and contouring systems is the dc motor powered from thyratrons, Ward Leonard drives, rotating amplifiers, magnetic amplifiers, and transistors. Thyratron-powered drives accept voltage signals from the program controller to produce proportional motor torque or speed output. Some thyratron controllers reverse motor rotation when the polarity of the input voltage is changed.

The thyratron-excited Ward Leonard drive is a versatile unit for program control applications. The thyratrons supply controlled excitation to one field winding of a dc generator. A second field winding receives a constant excitation adjusted to yield full voltage output. With no input signal, the thyratrons supply exactly enough current to cancel the fixed field, resulting in a zero generator output. A negative input signal reduces thyratron current, allowing the fixed field to dominate and the generator to produce a proportional output voltage. Similarly, a positive input to the thyratron control increases the excitation, squelching the fixed field and reversing generator polarity. This type of drive is manufactured in sizes up to hundreds of horsepower with extremely fast response times.

Rotating amplifiers such as the amplidyne are of important interest to the control engineer because of their high power gain and wide acceptance among designers of industrial equipment. The amplidyne is a motor-driven generator or amplifier having two gain stages built into a single rotary unit. Units of this type yield full power output (from ¼ to 25 kw) for less than 1 watt input.

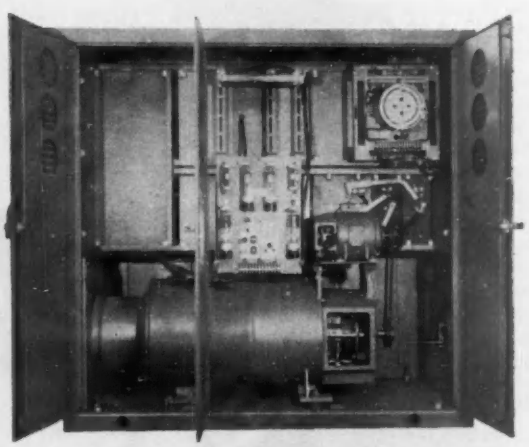
A drive incorporating the amplidyne does not respond as fast as do hydraulic drives because of the inertia of the dc positioning motor and the inductance of the amplidyne control-field winding. The control engineer can minimize the time delay introduced into the system by feeding the amplidyne control field from a high-impedance source.

Like hydraulic systems, amplidyne drives are relatively easy to stabilize if there is no appreciable backlash in the drive elements. But correcting networks are almost always needed due to the time delay in the amplidyne generator. It is frequently advantageous to employ rate feedback in the form of a tachometer generator directly coupled to the positioning motor.

The thyratron controlled dc generator described above has characteristics similar to the amplidyne generator, with the exception that the time constant of the control is somewhat less. This results in a faster system and somewhat simpler networks for servo stabilization. Because of its high cost, the use of this type of drive is generally confined to the higher-horsepower range.

Despite the fact that they have not as yet been widely used for this purpose, magnetic amplifiers provide a type of proportional power control suitable for programmed systems. The magnetic amplifier will accept dc control signals to produce dc output power for the operation of positioning motors. For this application, it has about the same characteristics as the amplidyne generator or the thyratron-controlled dc generator.

Magnetic amplifiers are more frequently arranged to control ac output power from dc signals. The output phase reverses if the polarity of the dc signal is changed. Such units used with two-phase ac servo motors will respond considerably faster than dc motor systems, since the ac motors are generally of lower inertia than dc motors. Magnetic amplifiers have been used successfully in low-power contouring.



Reliance 50-hp adjustable-speed dc drive features thyratron VSR regulator, motor-operated rheostat (top right), and two-bearing m-g set.

HYDRAULIC ACTUATORS

In contrast to electric units of equivalent rating, hydraulic actuators are smaller in size and exhibit much less inertia. These factors, coupled with the high stiffness characteristic of hydraulic motors and cylinders, are responsible for their high dynamic performance.

Probably the fastest response is obtainable from systems employing proportional hydraulic servovalves. A valve of this type controls the flow of oil to a rotary hydraulic motor driving a ball-bearing leadscrew. Such systems will give very fast positioning response and repeatability of a fraction of a thousandth of an inch, often without any special servo-correcting networks. The high frequency response of the valve and motor gives the servo designer a great freedom of choice of stabilization methods and final response. A simple lag network is sufficient to stabilize most high-gain systems having a repeatability of the order of plus or minus 0.0001 in. These results depend on the nut on the screw being free of backlash and there being no appreciable compliance in the drive members.

The ideal hydraulic motor for servo applications is the axial-piston or wobble-plate type, which features positive displacement and low leakage. Its operation is smooth despite the multi-cylinder construction and attendant valving. Axial-piston motors are widely available in the integral horsepower sizes where their advantages over electric motors are distinctly evident. Only very special conditions will justify the use of these motors in fractional-horsepower applications.

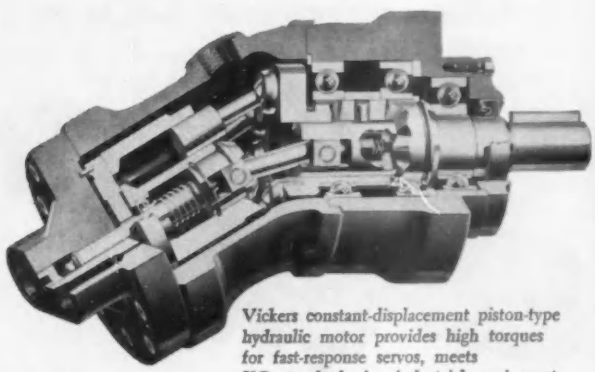
Vane-type motors are also used for hydraulic servos although some designers object to the leakage of oil through the motor and the resultant dead zone. The leakage of a good vane-type motor does not exceed 5 to 10 percent of the maximum displacement of the motor at rated speed and pressure. The dead band associated with this amount of leakage is actually small enough to provide satisfactory results in the majority of cases. Vane-type motors are less expensive than the piston type and have fewer wearing parts.

Hydraulic cylinders provide very fast linear speeds together with a smoothness of motion that is difficult to achieve by any other type of drive. Hence, the hydraulic cylinder makes a satisfactory positioning element for limited-travel mechanisms. The hydraulic cylinder does not respond as fast as will the combination of ball-bearing leadscrew and rotary hydraulic motor because the column of hydraulic oil is not as stiff or solid as a steel screw. The slight compressibility of the oil adds a compliance that limits the frequency response obtainable.

Hydraulic actuators are generally controlled by some form of electrically operated proportional valve. In one type of valve the control spool is moved directly by a torque motor or solenoid. Such valves are essentially low-capacity devices and are less sensitive electrically than amplifier types. Some piston-type valves are equipped with a follow-up piston connected by a linkage to a sleeve around the pilot spool. This increases the sensitivity and the amount of power that can be handled.

Hydraulic-amplifier valves are more sensitive than the direct operated units and are available in sizes up to 100 hp at pressures to 3,000 psi. The amplifier valve uses a small vane deflected by the torque motor to obstruct oil flow from one or two small orifices. The resultant change in pressure behind the orifice shifts a power spool that regulates oil flow to the external load. The better valves have two orifices with the vane situated between them in the manner of "force-balance" construction. Some valves use spring feedback from the power spool to the control vane to provide higher sensitivity and permit higher forces on the main spool. The small amplifier orifices cannot tolerate accumulations of dirt. For this reason valves of the "dry coil" type are of interest since they do not tend so readily to collect magnetic particles from the oil. In any case, full-flow filters should be included in the supply line to the valves.

The piping between servovalve and actuator should be as short and rigid as possible. Flexible lines introduce another compliance in the servo loop, with consequent deterioration in performance. Because long pipes mean larger volumes of oil, the servovalve should be mounted directly on the hydraulic motor with an appropriate adapter plate where possible. This will completely eliminate the piping between the motor and the valve, leaving only the supply and drain lines to be provided.



Vickers constant-displacement piston-type hydraulic motor provides high torques for fast-response servos, meets JIC standards for industrial equipment.

MECHANICAL LINKS

In positioning and contouring systems, it is usually necessary to convert the rotary motion of a prime mover into linear machine motion. The mechanical design of this link—a leadscrew in most cases—has a vital effect on performance. The Acme-thread screw that is regarded as standard in conventional machine-tool drives has inherent rigidity and high mechanical advantage, but is subject to backlash and friction. Despite this, accurate position control systems can be built with the conventional leadscrew. Careful controller design is essential and some sacrifice in speed of positioning may be necessary.

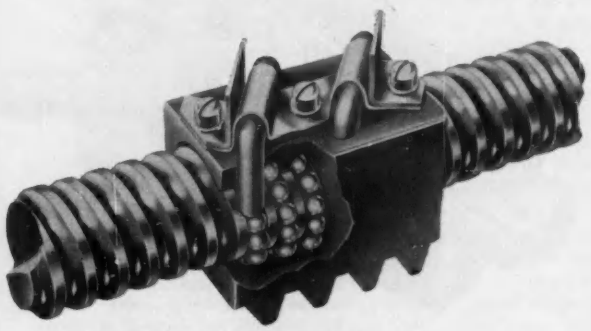
The trend now is to use ball-bearing leadscrews for the positioning drive element. Heavy load-carrying capacity, freedom from backlash and friction, and long life combine to make this an important drive element for machine tools. Many designers rate the combination of a preloaded ball-bearing screw and a rotary hydraulic motor controlled by a proportional servovalve as the most rigid and fastest drive available.

For travel distances over a limit of about 10 ft, the

leadscrew is frequently ruled out in favor of the rack and pinion. Racks can be made as long as desired, but may exhibit greater backlash tendencies than leadscrews. Backlash in a rack and pinion drive can be reduced by using two pinions with some form of adjustment or preload between them.

The design of leadscrew or rack and pinion is normally regarded as being under the jurisdiction of the machine designer. Yet, the control engineer must be prepared at least to make general recommendations on their choice and application. The reason is that the leadscrew or pinion in most cases carries the feedback transducer or data element and has therefore a vital effect on overall system accuracy. And, even when the data element is of the linear type and mounted independently of the drive, mechanical elements may have a direct influence on accuracy.

In one such case involving a hydraulically servoed machine, instability was encountered that could not be overcome either by greatly reducing the gain or by adopting any reasonable lead or lag networks to



Schematic of Saginaw ball-bearing leadscrew.

modify the error signal. Careful observation revealed that the error signal would increase when the machine drive reversed its direction, and then decrease after the machine drive had moved through an appreciable distance. Obviously, the machine data element was moving in a positive direction for a short distance while the leadscrew was attempting to drive it in a negative direction. This was caused by a tendency of the machine slide to rotate around a point lying between the leadscrew and the linear data element. The fault was cured by reworking the machine slide properly to prevent the rotation. The servo could have been stabilized by mounting the leadscrew and the linear data element on essentially the same line so that there could be no relative motion between them. While helpful to servo operation, such an approach would not cause the machine to perform satisfactorily.

PROPORTIONAL VS. DISCONTINUOUS SERVOS

Potentially, the discontinuous (relay) servo is capable of much faster response than the proportional servo, because the actuator is operated at full speed for a greater portion of the time. However, to realize such potential with acceptable stopping accuracy, the control engineer must provide rather complex computing circuits to continuously adjust the actuator cut-off point as a function of speed, inertia and other variables. In industrial applications, the inclusion of such elaborate computer circuitry cannot usually be justified economically.

Hence, from a practical standpoint, the proportional servo is the designer's choice when fast response is wanted. In addition, this type of system has the advantage of correcting errors that may be introduced by vibration, cutting loads, and the like. This latter characteristic is of especial interest in applications where no clamping is provided. In high-precision equipment such as jig borers, however, this factor is surprisingly of less importance, since the servos are always disconnected and the machine members clamped after positioning because any spurious movement is intolerable.

Discontinuous servos have been widely employed up to now because they are less expensive, although of somewhat lower speed of response than the proportional servos. Some positioning systems use what is called a "slow down and stop" technique. One such application features a polarity-sensing circuit for determining the direction that must be followed to reach the desired setpoint. A slow-down relay operated from the coarse data element closes a relay at a distance of about 3 in. from setpoint. A second slow-down relay operates at about 0.5 to 0.3 in. from the setpoint. Lastly, a stop relay operates within the region of 0.003 to 0.001 in. from setpoint.

The slow-down and stop positioning system is not as fast as a continuous servo system, but it does provide accurate results with relatively inexpensive equipment. Large machines whose positioning time is a relatively small portion of the total operating time use this program successfully. The speed changes in a slow-down and stop system can be obtained from clutch-controlled gearing, multispeed motors, or adjustable-speed dc motors. The thyratron drive with tachometer feedback is an excellent combination for this purpose. The final approach speed must be fairly consistent to obtain repeatable coasting distances after the stop relay operates.

Another form of discontinuous servo that has been used successfully employs a cyclic approach to the desired final position. In this system, the machine approaches the setpoint at high speed. At setpoint the motor is de-energized but the machine is allowed to overshoot as much as 0.1 in. The motor is then reversed and the gear ratio changed to drive the machine backwards at a reduced rate. After passing the setpoint in the reverse direction, the machine is again reversed and the speed reduced still further for a final approach. The final approach speed is about 0.3 in. per min. After setpoint is reached, the motor is against reversed to move the machine a distance equal to half of the total backlash for stress relief.

The slow-down-and-stop system must have properly controlled slow-down points or the machine may overshoot the setpoint. The cyclic positioning system, on the other hand, does not depend on the relationship between the slow-down and the stop points for proper operation. Neither system is particularly sensitive to backlash. In fact, the cyclic system operates better with some backlash because it is easier to relieve the tension in the screw or other portions of the drive when this backlash is appreciable.

PROGRAM CONTROL APPLIED

While planning and preparing this special report on program controllers and program-control design techniques, Control Engineering editors were impressed by many things: the technical ingenuity evident in the controlled machines and processes; the surprising growth of the "program-control content" in new systems; and the dynamic nature of the field. Scores of applications were uncovered in all industry classifications—material processing, heavy machinery, aircraft and missile—that brought these factors into dramatic focus. The following pages describe 12 applications that are of particular interest, because they serve, incidentally, to document areas of growth and the types of performance that program control makes possible. More importantly, these pages present detailed system studies that will supplement the basic material already presented and show how it can be put to use.

1. Line-Programmed Flame Cutter

J. S. CHEVERTON, Canadian Westinghouse Co., Ltd.
KENNETH LOSCH, Westinghouse Electric Corp.

Although line-following tracer systems for gas cutting are obviously more easily programmed than metal-template tracers, line followers usually require special drawings, and sometimes even photographic negatives. In addition, conventional line tracers follow only the edges of the pattern lines, which must be heavy (about $\frac{1}{8}$ in. in breadth). In contrast, the newly developed Westinghouse Linatrol equipment needs only the simplest possible templates: pencil outline drawings on plain paper. Normal variations in the density or width of the pencil line do not affect the final results; the tracing error of the system is below plus or minus 0.01 in. even on sharp turns at maximum cutting speed. The tracer is inherently "drift-free" from external disturbances such as voltage fluctuations,

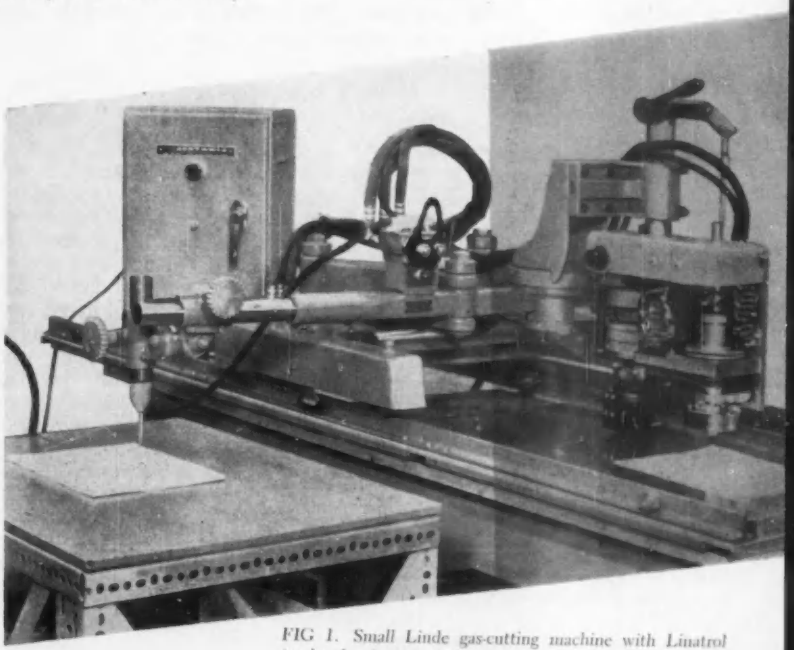


FIG 1. Small Linde gas-cutting machine with Linatrol tracing head. Pen (left) replaces torch in demonstration.

changes in ambient light, and temperature.

The system employs a photoelectric sensing element coupled to a null-seeking ac servo. When this element is positioned over the illuminated line on a pattern, null output is obtained. Any misalignment between the sensing element and the line on the pattern produces an output voltage that is amplified and applied to the servo to steer the sensing element into correspondence with the line drawn on the pattern. Figure 1 shows Linatrol equipment, consisting of tracing head, electronic control unit, and remote switch unit, installed on a gas-cutting machine.

Tracing head

The tracing head contains steering motor, optical system, and four control switches, one of which is cable-connected for remote operation. This head is fitted to the tracking or drive head of the gas-cutting machine and houses an adjustable-speed motor coupled to a drive wheel, Figure 2. The steering motor is geared to the vertical column carrying the drive wheel. This column is in turn coupled through one-to-one gearing to the upper section of the optical assembly. Thus, one revolution of the steering column imparts one revolution to the scanning photocell, housed in the upper section of the optical assembly. The two-phase, 60-cycle steering motor incorporates a tachometer-generator.

The lower section of optical system is rigidly mounted to the frame of the tracing head and carries a biconvex lens, so positioned that it throws the image of a small portion of the pencil-line pattern onto the photocell. The pattern is illuminated by four small lamps equally spaced around the lens mount.

The upper section of the optical assembly houses the photocell (which is made to vibrate) and carries four slip rings for electrical connections. The photocell is attached to one end of a rigid bar. The other end of this bar carries a small U-shaped permanent magnet with poles facing away from the photocell. The bar is mounted centrally within the optical assembly by means of a horizontal flat torsion spring, whose axis is perpendicular to a line through the poles of the magnet. Directly above the permanent magnet is an E-shaped electromagnet, so located that the poles of both magnets lie in a common vertical plane. The magnet coil produces a 60-cycle alternating field that forces the U-magnet from side to side and sets the photocell vibrating about its mean position.

The direction of the photocell oscillations in relation to the travel of the drive wheel is such that the image of the line of the pattern is scanned perpendicularly. The photocell is offset from the vertical axis of the optical system so that it scans slightly ahead of the position on the pattern directly below. If, as the optical system is moved across the pattern, the optical axis does not remain exactly above the line of the pattern, the photocell will not scan the image of the line symmetrically. This asymmetry causes the photocell to produce specific electrical signals for left and right errors, depending upon whether the optical axis moves to the left or the right of the line being traced.

When the optical axis is immediately over the line of the pattern, the photocell has focused upon it equal amounts of light during each half of its swing. Since the photocell vibrates at 60 cps, its signal is double frequency or 120 cps. When the line of the pattern is displaced relative to the center of vibration, the cell receives two different amounts of light during each half of its swing. This results in a signal containing a line-frequency component whose phase, relative to that of the line, depends upon which side of the center of vibration the line on the drawing is displaced.

The portion of the error signal at line frequency is phase-adjusted, amplified and used to supply the control winding of the two-phase servomotor. This motor is geared to steer the tracing head in such a way that it will always reduce the error between the line of the pattern and the vertical axis of the optical scanning device. Thus, while the driving motor moves the entire tracing head across the drawing, the steering motor maintains the scanning head directly above the line.

The offset of the photocell, which causes it to scan the pattern slightly ahead of a point immediately below the cell, provides phase advance to the closed-loop steering servomechanism. This technique assists in stabilizing the system, and eliminates steering direction ambiguities at sharp corners on the pattern.

The optical system is designed to follow a dark line on a lighter background, thereby making pencil lines on white paper satisfactory. If a more durable pattern is desired, a black ink line on a light-colored card is recommended. Because the photocells used are red sensitive, red lines on the pattern appear to the photocell as very light lines and cannot be traced. Thus, operators' notes may be written on the pattern in red without interfering with automatic tracing.

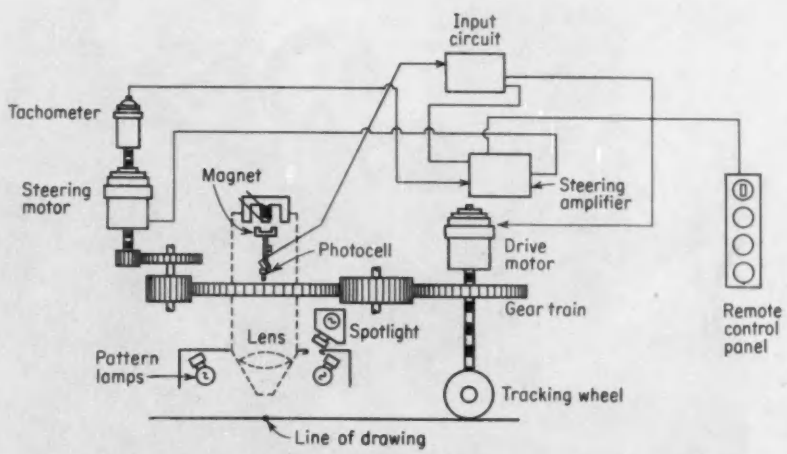


FIG. 2. A schematic drawing of a gas cutting machine tracing head, showing the control equipment.

Electronic control

The control enclosure contains a steering amplifier and all necessary power supplies. The amplifier consists essentially of an ac preamplifier, a filter circuit to extract the 60-cycle component of the steering signals, and a power amplifier for energizing the control winding of the steering motor. The use of an ac amplifier prevents response to changes of light, voltage, or any expected variable other than the line contours on the pattern. A part of the tachometer generator output is fed back to the power amplifier to oppose movement and has the effect of damping the system, preventing any tendency to hunt.

2. Tape-Controlled Diffractometer

W. A. WOOSTER, Brooklyn Crystallographic Laboratory, Cambridge, England

X-ray diffraction is a technique for investigating the properties and lattice structure of crystals. In one method of making such studies, the crystal under analysis is mounted midway between a stationary source of X-rays and a detector, consisting of a Geiger or scintillation counter. The detector mount can be caused to rotate around the crystal, making it possible for the analyst to scan for the diffracted beams of greatest strength. In addition, the sample holder can be rotated about its axes to present various faces of the crystal to the X-ray source. A complete diffraction test is a long and tedious routine involving repeated rotation of both crystal and detector through small angles.

In the fully automatic X-ray diffractometer, Figure 1, the repeated movement of both crystal and detector around the vertical axis is programmed from punched tape. In addition to these motions, the crystal can be rotated through 360 deg in the vertical plane. A separate tape-programmed dc motor drives the crystal through this vertical circle.

Horizontal-circle movements are powered through two gear trains by a 40-watt synchronous motor operating continuously. One gear train provides fast rotation at 100 deg per min; the second is a six-position train that makes possible rotation at 8, 4, 2, 1, ½, and ¼ deg per min. The desired speed is obtained by energizing magnetic clutches between the gear trains and the wormwheel drive shafts.

Each line of the standard five-channel tape used for programming can be punched with one of a total of 30 possible hole combinations. Only 16 of these hole configurations are assigned to position and speed information. The remainder is available for control of auxiliary equipment such as a furnace or cryostat that may be used with the diffractometer.

Input information from the tape reader feeds a relay store, Figure 2, which sets the appropriate speed clutches for the crystal and detector heads. In setting to precise positions, each punching on the tape advances the heads through discrete increments of 1, ½ or ⅒ deg. These increments are measured by three cams mounted on each of the wormshafts that drive the 360-tooth wheels. The cams operate limit switches for each 1, ½ and ⅒ revolution of the wormshaft. When a movement is to be made, the code on the tape energizes a magnetic clutch and, simultaneously, selects one of the limit switches to break the energization circuit when the wormshaft has turned through the corresponding length of arc. In addition to disengaging the clutch, the limit switch applies a start signal to the Geiger or scintillation counter. When a predetermined count has been recorded the tape is automatically advanced and the heads rotate to a new position.

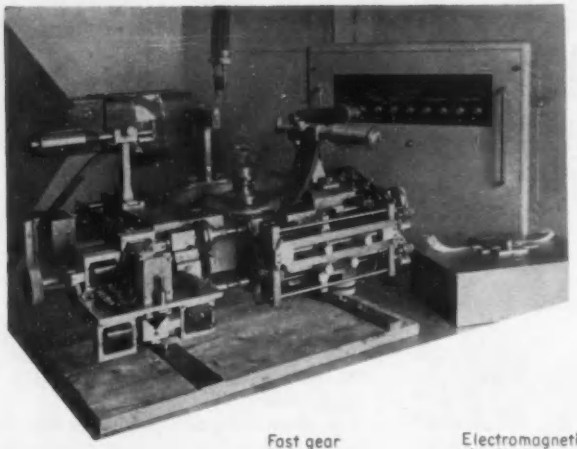


FIG. 1. Punched-tape control of the X-ray defractometer provides automatic study of crystal zones.

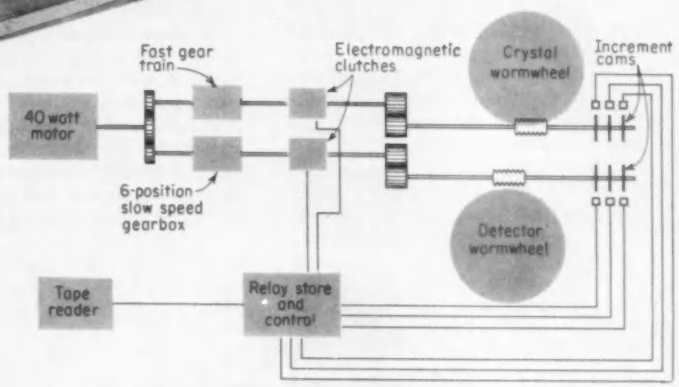


FIG. 2. Basic schematic of punched-tape-controlled diffractometer.

Where the heads are to go through large angles of motion before a reading is taken, the movements are still made in increments but at rapid traverse of 100 deg per min up to 1 deg of the final position. Then the tape programs a slow-speed final approach to ensure positioning accuracies of plus or minus 1/100 deg, or better.

For continuous scanning between preset limits, the tape selects the appropriate magnetic clutch for the wormwheel that is to drive the scanning process. The rotational limits are set up by stops on a calibrated scale. At the end of the chosen arc, a traveling nut geared to the drive shaft actuates a specially designed reversing switch.

3. Blooming Mill Screwdown Control

K. REED THOMPSON, Industry Control Dept., General Electric Co.

In the typical blooming mill hot steel ingots are passed back and forth between work rolls to reduce their cross sectional area. On each such pass the operator adjusts the opening between the work rolls, selects the proper speed and direction of these rolls, and sets the direction of the table rolls on each side of the mill. On some passes, he must also turn the ingot 90 or 180 deg by operating the sideguards and manipulator fingers. Auxiliary functions, such as descaling sprays, must also be initiated by the operator.

Recent years have seen greater demands placed on blooming mill operation, from the standpoints of both the quantity and variety of product. This has stimulated attempts to place this part of the steel-making process on a more automatic basis. Numerical program control offers tremendous potential as a means to this end and a number of applications have actually been made, with three principal benefits resulting: increased production, improved product, and a reduction in the skill required of the operator.

The systems installed to-date include automatic and semi-automatic types. In both cases, the functions that are numerical in nature, such as horizontal- and vertical-roll positioning, mill speed limit, and draft compensation, are programmed. These are setup operations and may be initiated simultaneously from one pushbutton. In a semi-automatic program, the sequencing functions are retained by the operator. These functions include starting and stopping the mill, initiating slowdown and acceleration at the proper time, and operating the manipulator.

A block diagram of the program controls for roll positioning or screwdown is given in Figure 1. The card reader produces a number signal which is recoded and fed to digital-to-analog converter. The latter is an arrangement of tapped transformers that produces a command voltage equivalent to the desired screwdown setting. The dc screwdown drive motor is powered from an m-g set, the voltage of which is adjusted as a function of the amplified error signals. One or more synchros geared to the screwdown drive mechanism provide feedback of the position of the rolls.

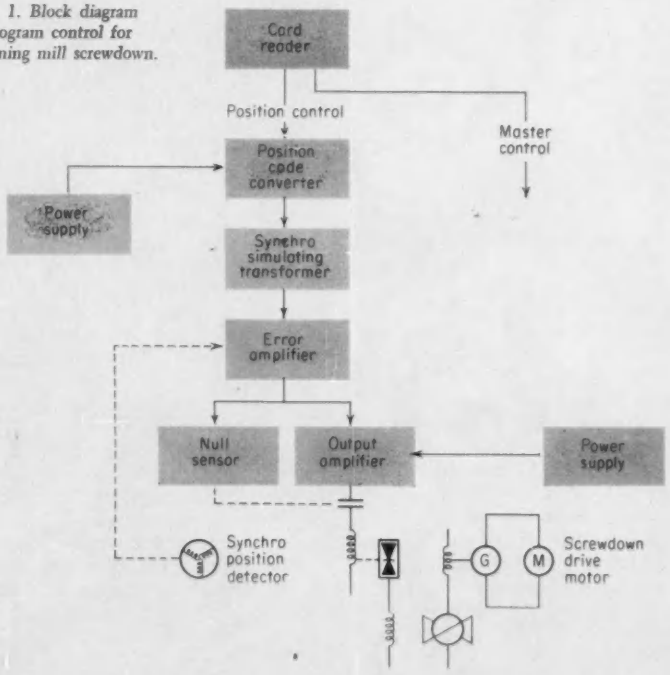


FIG. 1. Block diagram of program control for blooming mill screwdown.

Data storage and readout

Data is inserted into the system by means of punched cards using binary-coded decimal numbers. The information required for one pass is included in one horizontal row, Figure 2. The card reader is of the static type; that is, the card remains stationary while all holes are sensed. This static system not only improved reliability but allows the card to double as the buffer storage element.

Before any data is read, the card position and alignment are checked. Holes are punched in three corners of the card to allow this check. To read information into the system, the circuits associated with the horizontal card rows are energized sequentially. Figure 3 shows a portion of the reading circuits for a card. One readout circuit is provided for each card column. The diodes shown furnish the isolation needed between horizontal rows. Relay interlocks energize rows at the proper time. A program requiring the use of the entire card involves a total of 960 reading circuits.

A static-switching matrix converts binary-coded decimal information on the card into a usable decimal form. The four binary numbers for each decimal digit are translated by a group of 10 static switching units, five of which are shown in Figure 4. Any particular combination of the four card signals is recognized by only one of these static switching units, which will then become energized as a decimal interpretation of the binary signal. This logic unit energizes a relay, which is the readout element of the code converter. A numbered monitor light on these relays gives a decimal readout of the decoded number.

The selection of individual rows on the card for reading is made by means of a stepping-ladder circuit, which sequentially energizes a group of output relays. These relays carry the interlock contacts shown in Figure 3.

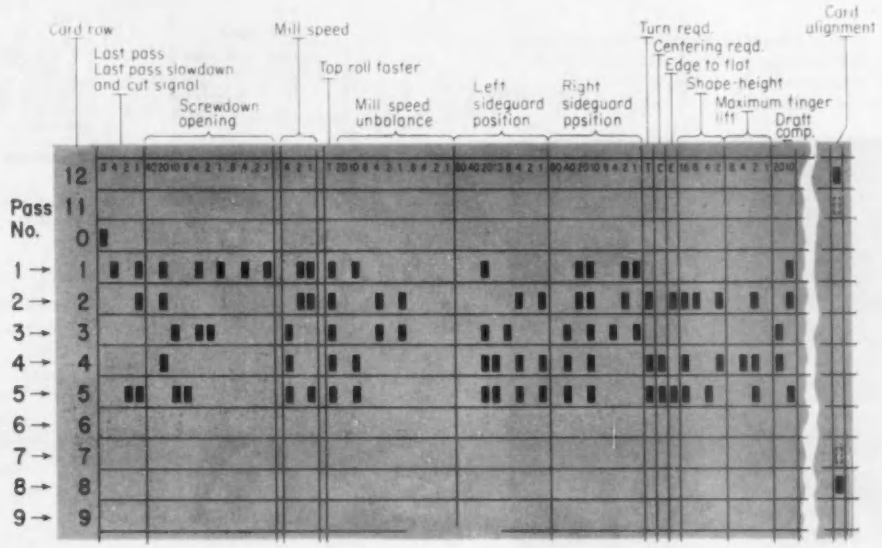


FIG. 2. Sample card containing data for positioning screwdown and sideguards, and for sequencing the main mill drive and manipulator.

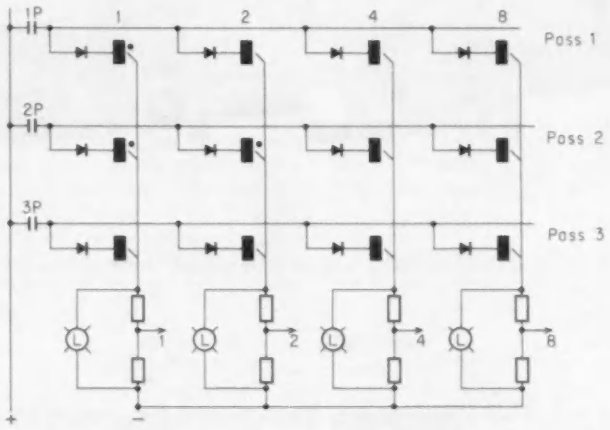


FIG. 3. Schematic diagram of portion of the reading circuits in static card reader.

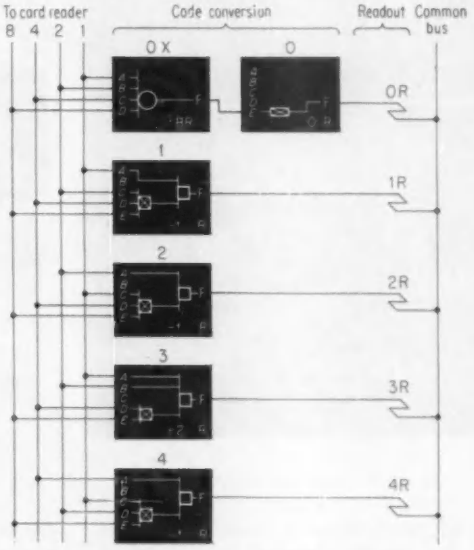


FIG. 4. Five lines of static-switching matrix for converting binary-coded decimal signals into conventional decimal form.

The actuating signals for the stepping ladder are provided by a pulse generator. Both ladder and pulse generator are made up entirely of static switching elements.

Synchro-simulating transformer

The command signals for the positioning servos are derived from a synchro-simulating transformer, Figure 5. This transformer has taps arranged to provide a group of voltages, each corresponding to a definite rotor position of a reference synchro. Thus a given synchro position can be simulated by energizing a relay associated with the proper tap. To make the system compatible with numerical techniques, a transformer winding capable of simulating 10 discrete synchro positions was chosen, Figure 5A.

The 10 rotor positions correspond to increments of only 36 deg each, but synchro resolution is actually much better than this. Therefore, a technique for taking advantage of the available resolving power was sought. The technique chosen was to add a second winding to the simulating transformer. This winding produces a voltage equal to that obtained from a reference synchro after turning its rotor through 36 deg (1/10 rev). The auxiliary winding has 10 taps, each yielding a voltage equivalent to a 3.6-deg increment of synchro rotation. Thus, with the two windings arranged as shown in Figure 5B, it is possible to select command signals simulating synchro rotation from 0 to 360 deg in 1/100-rev increments. Since the particular synchros used have a resolving power in excess of 1/1,000 revolution, it is possible to extend the philosophy of interpolation by use of a 10 to 1 step-down transformer, Figure 5C. This provides 10 points

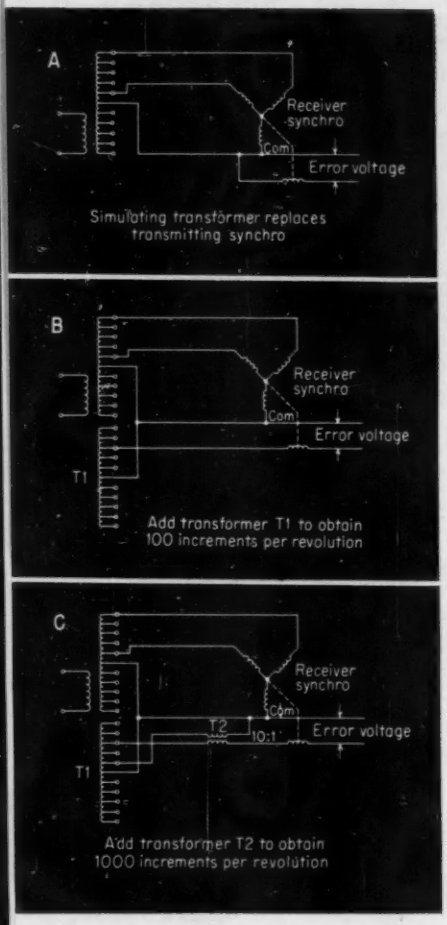


FIG. 5. Digital-to-analog converters for generating command signals for positioning servos. Discrimination levels are 1 part in 10, 1 part in 100, and 1 part in 1,000 for circuits A, B and C, respectively.

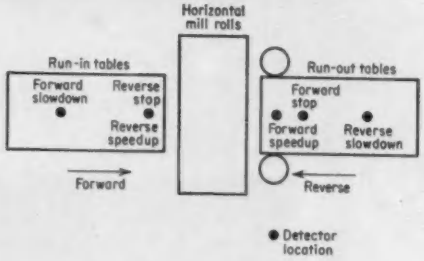


FIG. 6. Typical arrangement of hot-metal detectors for completely automatic mill control.

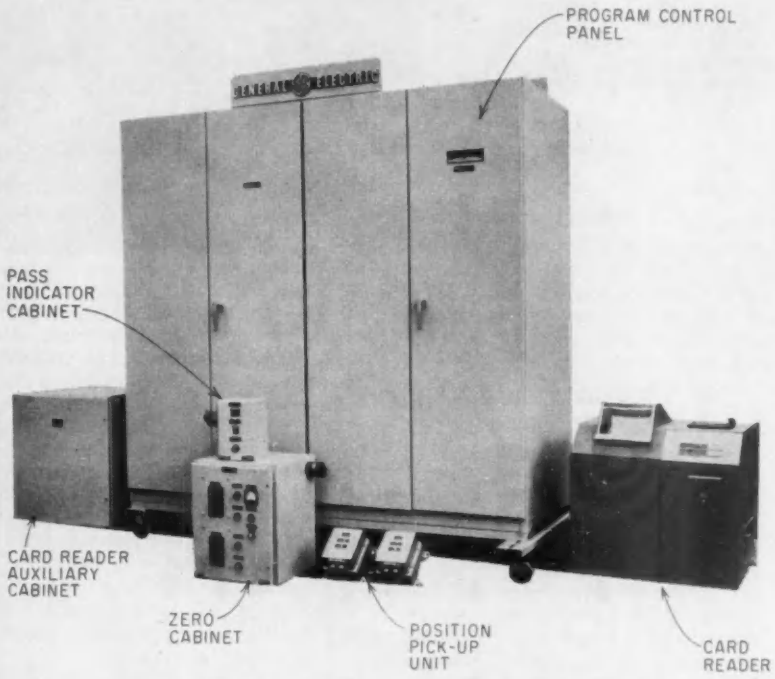


FIG. 7. Equipment packages for programmed screwdown control of blooming mill.

of interpolation between each of the 100 already obtained, for a total of 1,000 discrete positions.

Fully automatic mill control

With the addition of the required sensors to the semi-automatic system described above, the program may be made completely automatic. Some examples of sensors that may be employed to detect and follow metal through the schedule of operations are limit switches, hot-metal detectors, mechanical strain gages and stall-condition detectors. The hot-metal detector in use contains a solid-state photo-voltaic cell, particularly sensitive in the infrared range. This is augmented by an infrared filter to reduce the effect of ambient light, thus permitting accurate sensing of hot metal even in adverse steam and dust environments. By operating two detectors in parallel at each sensing location in a fail-safe scheme, the mill operation may be continued even if one of a pair fails.

Figure 6 shows one arrangement of hot-metal detectors for a fully automatic program. The operator manually brings an ingot onto the run-in table, then presses a pushbutton to initiate readout of the first-pass information from the card. Positioning of the horizontal and vertical mill rolls and the sideguards is begun, and when the desired positions are almost reached, the mill starts forward at the entry speed. As the leading edge of the metal approaches the "forward speedup" metal detector, the mill accelerates to the programmed entry speed (compensated for draft).

As it leaves the "forward slowdown" detector, the trailing edge of metal initiates a time-delay circuit. The actual slowdown operation is thus delayed as a function of mill running speed, until just enough time remains to bring the mill down to delivery speed. As the trailing edge leaves it, the "forward stop" detector stops the mill and initiates readout of data for the reverse pass. In this run, the "reverse speedup," "reverse slowdown", and "reverse stop" metal detectors have control.

On mills where manipulation of the piece during rolling is required, an automatic sequence may be interrupted to allow the operator to manually turn the piece. During the automatic sequence, the operator's duties change from actually rolling the metal to supervising the rolling. He may interrupt the automatic sequence and assume control in such eventualities as a split end or failure of an ingot to enter the mill.

4. Curve Followers Program Heat Runs

J. W. POWELL, Boeing Airplane Co.

A 5,000-kva radiant heating system is now in use at Boeing to simulate the heating conditions encountered by a missile during its re-entry into the earth's atmosphere. The test facility employs groups of infrared radiant lamps located in a "high-bay" area, Figure 1. The power for these lamps is supplied through banks of ignitrons and saturable reactors to permit wide range control of the test temperatures. The regulating action of the ignitrons and reactors is automatically programmed from computers equipped with 16 curve followers.

The purpose of a control computer is to provide a convenient way for simulating the thermal characteristics of a desired flight path. Transient aerodynamic heating is largely a forced type of heat transfer. To simulate such heating by radiant units, their output must be controlled so that the heat absorbed by the specimen will conform to that of the transient flight path. The control system must express the flight-path transfer rate in terms of the heat transferred to the specimen by the oven. The type of control consists essentially of an electronic analog computer, into which heat transfer temperature and the recovery temperature are entered as functions of time.

The specimen surface temperature is fed to the computer by means of a thermocouple. The computer determines the required heat transfer rate to simulate the required flight path. Another part of the computer determines the power into the radiant heating elements and the heat transfer rate actually occurring. The required and actual heating rates are compared, the difference being an error signal that is supplied to the control unit. The delivered power is then automatically altered in accordance with the sign of the error signal until the difference is zero.

There are 24 ignitron-controlled power supplies mounted on castors to allow flexibility in the choice of test location. The 10 reactor controlled units are permanently mounted for small-scale tests that can be conveniently set up in the area.

The system requires 12 channels of control computers capable of continuously satisfying the forced convective heat transfer equation

$$Q = H(T_{AW} - T_S)$$

or capable of controlling the power units on a specimen temperature vs. time basis. The computer is equipped with 16 curve followers, which provide 12 heat transfer coefficients (H) and four adiabatic wall temperatures (T_{AW}). These values are programmed as functions of time by means of curves drawn with conducting ink on drums. These drums are driven by a time function generator, adjustable from 20 to 1,020 sec.

System schematic

The control loop is pictured in Figure 2. Incoming power is received by the ignitron power unit that controls the power delivered to the radiant heating units arrayed about a test specimen. A thermocouple located on the specimen measures surface temperature T_s, which is recorded on a Leeds & Northrup strip chart. The temperature signal is also combined in a summing amplifier with a signal representing the adiabatic wall temperature. This combined signal, $(T_{AW} - T_S)$, is modified further in a multiplying circuit by a signal that is an analog of the "heat transfer coefficient" for a particular flight profile. The combination $H(T_{AW} - T_S)$ represents the forced convective heating factors from the complete heat-balance equation and is proportional to the input power required. The computer-controller compares the input requirement with the feedback measurement.

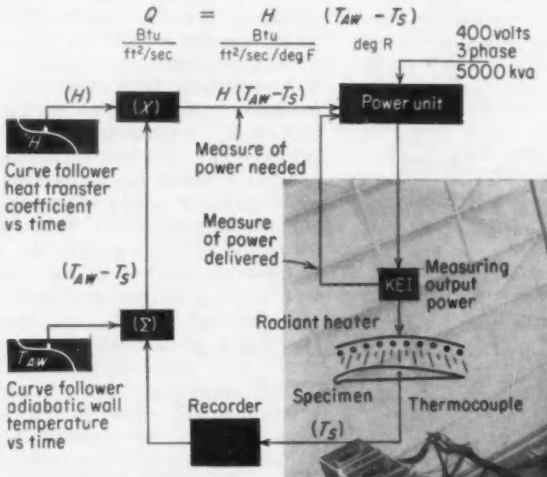


FIG. 2. Schematic diagram of heater control loop.

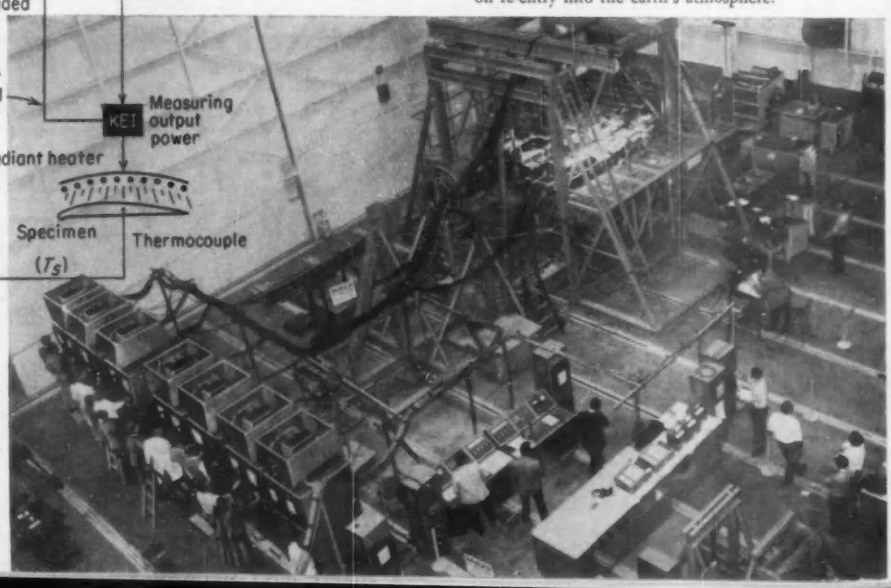


FIG. 1. View of test facility used to simulate heating effects encountered by missiles on re-entry into the earth's atmosphere.

5. Automatic Treatment of Acid Wastes

C. G. BUELTMAN, The Permutit Co.

The application of distributed program-control techniques makes possible completely automatic treatment of chromic-acid wastes. The system to be described has been installed at the Woodstock, Ill., plant of Electric Auto-Lite Co. (Die Casting Div.). The automotive products made at this plant require the use of chrome-plating processes. The wastes from these processes consist of the chromic-acid solutions and the waters that are used for rinsing.

The waste treatment system, Figure 1, has three principal benefits:

1. It recovers chromic acid for reuse.
2. It detoxicates the waste sufficiently to permit disposal of it in a municipal sewer.
3. Its by-product is demineralized water, the equivalent of a high-quality distilled water.

The chemistry of the treatment involves the passage of the wastes through ion-exchange columns. The resins used in these columns have a capacity for exchanging a finite quantity of chemical ions per unit volume of resin. Two types of resins are used. The first is acid-regenerated cation resin, which exchanges hydrogen ions for metallic cations such as calcium, magnesium, sodium, and tri-valent chromium. The other is caustic-regenerated anion resin, which exchanges hydroxyl ions for chlorides, sulphates, and hexavalent chromium. After a period of use, the resins can be regenerated by applying high concentrations of acid or caustic to reverse the chemical reaction. The combination of an acid-regenerated cation unit and a caustic regenerated anion unit, exchanging hydrogen and hydroxyl ions in solution, produces the demineralized water.

The basic operations in an ion exchange system consist of:

1. *Service*—passage of solution to be treated through the ion-exchange columns.
2. *Product rinsing*—purging the solution being treated from the ion-exchange columns prior to regeneration of the resins. This prevents discharge of toxic or recoverable constituents to waste during the regeneration cycles.
3. *Backwashing*—the passage of water through an ion-exchange column to loosen and re-grade the resin bed, and to remove any foreign matter entering the resin bed during the service cycle.
4. *Regenerant introduction*—admission of regenerant (acid or caustic) at a predetermined concentration and rate.
5. *Slow rinse*—displacement of the regenerant from the resin bed.
6. *Fast rinse*—purging the resin bed of residual traces of regenerant prior to placing the ion exchange columns back in service.

The prime function in making the waste treatment automatic is the control of flow. Depending on the part of the process involved, this control of flow is programmed on the basis of time, concentration, or volume. The distributed approach to program control was chosen because the operating cycle is relatively fixed. In addition, this type of control is very adaptable to the use of different bases (time, volume, etc.) at various stages in the cycle. The accompanying table lists the operations and control factors.

During the service cycle, or treatment of solution, the controlling factor is concentration. The objective here is to monitor the "strength" or exchange capacity of the resin and to cut off the flow through the column when this capacity is exhausted. If the waste solution is of constant concentration, a known volume of solution can be treated before exhaustion of the resin. Thus, control can be effected through volumetric meters. Where solution concentration is variable, volume is no longer a reliable criterion and conductivity instruments must be employed. As the ion-exchange capacity of the resin is depleted, the mineral concentration in the effluent from the ion exchange columns increases. This increased concentration is accompanied by a rise in the conductivity of the effluent, which can be sensed by a conductivity instrument.

Product rinse takes place when the ion-exchange units must be purged with water so that no toxic or recoverable products will be discharged to waste in the following regeneration cycles. This is primarily a rate and volume control problem. Backwashing for cleansing and re-grading the resin involves the control of the rate of flow over a given period of time.

Regenerant introduction involves applying a predetermined concentration of acid or caustic at a rate that permits proper exchange to take place, and in sufficient volume to effect complete chemical regeneration of the resin with the proper quantities of exchangeable ions.

The slow rinse is accomplished by applying a known quantity of purging water over a length of time sufficient to permit adequate displacement of the regenerant solutions from the

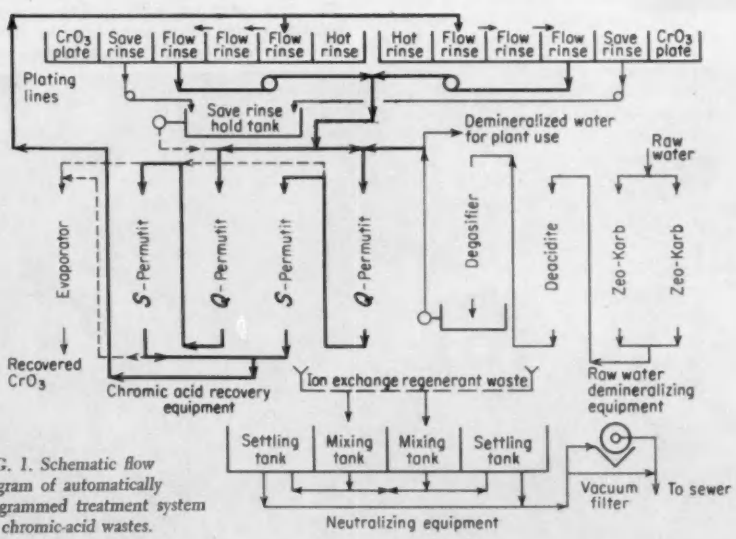


FIG. 1. Schematic flow diagram of automatically programmed treatment system for chromic-acid wastes.

ion-exchange columns. This is followed by a fast rinse to purge any residual traces of regenerant. While volume is the variable of interest, the flow rate is known so that this part of the cycle can be adequately programmed on a time base.

Program control

It is evident from the cycle diagram, Figure 2, that in practically all instances, a timer can be used as the program controller. The initiation of the regeneration cycle, however, requires either a volume totalizer or conductivity meter. The fast rinse operation, although generally controlled by a timer, can also be programmed on the basis of conductivity. Then it is terminated by low conductivity measurements, indicating less contamination in the water.

The chromic-acid recovery ion-exchange units treat an effluent solution having varying concentration. Therefore, the end of the service step must be signaled by a conductivity instrument, which starts the timer for the regeneration cycle. The raw-water demineralizing system, on the other hand, treats water of constant concentration. Hence, volume meters are employed to stop the service operation and initiate regeneration.

A conductivity instrument monitors the effluent of the raw-water-demineralizing units. If the concentration of the effluent should increase, thereby reducing the volume of water that can be treated satisfactorily in the service cycle, the conductivity instrument will override the volume meters to end the service cycle and start regeneration.

The regeneration of ion-exchange resins is a critical phase in this operation. It is essential that a given concentration of regenerant be in contact with the resin for a definite period of time and that a predetermined quantity of regenerant come in contact with the resin. In the process, a concentrated regenerant is diluted with water in a pipe-line mixing chamber, then introduced into the ion-exchange column. Because the retention time in the mixing chamber is a matter of seconds, the flow rate of dilution water and the rate and concentration of concentrated regenerant must be held under strict control. Flow meters with alarm contacts insure proper mixing and dilution of the concentrated regenerant. If the water flow rate should become excessive, or should drop to a lower rate than is desirable, the alarm contacts will shut this step down.

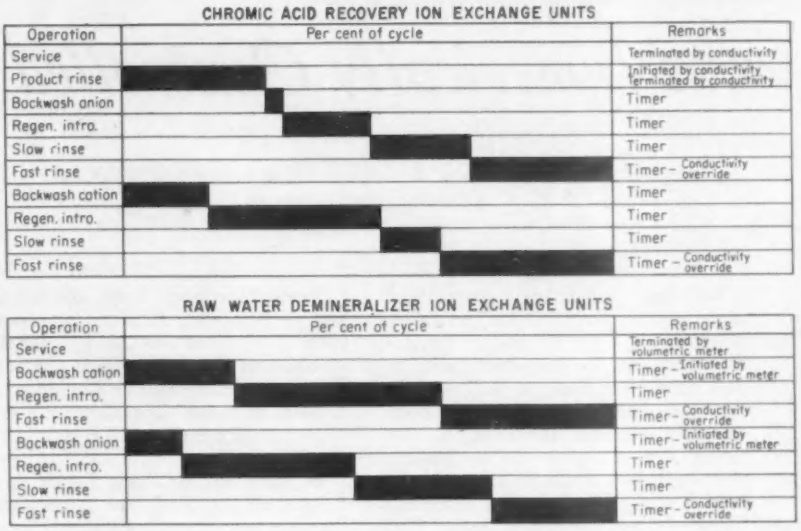


FIG. 2. Cycle diagrams for chromic-acid-recovery and water-demineralization units under program control.

Neutralizing

The third system step in the waste-treatment process is neutralizing the waste regenerants from the ion-exchange system. Neutralization is basically a batch-type operation, again under fully automatic control. The regenerant wastes discharge into either one of two mixing tanks until that tank is full. While the second mixing tank is filling, the contents of the first tank are being neutralized by the automatic addition of lime as called for by a pH-measuring instrument. When the desired pH level is obtained, the lime feed is cut off and the contents of the mixing tank pumped to a settling tank. The pH-adjusted contents of the two mixing tanks are fed alternately into a settling tank until it is full.

Level controls initiate the diversion of the mixing-tank output into a second settling tank. The contents of the first settling tank are then allowed to rest for a timed interval to permit the separation of the sludge formed during neutralizing. Next, the supernatant is withdrawn through a swing pipe and discharged into the sewer.

The discharge of the supernatant solution to the sewer is monitored by a photoelectric sludge blow-off control, which senses the amount of suspended matter contained in the supernatant discharge. When the settling tank has been emptied to the level where the settled sludge or suspended precipitates begin to enter the sewer, the blow-off control shuts down the discharge to the sewer. This same control starts an agitator to produce a uniform slurry of sludge and acts to divert the slurry drawn off from the settling tank to a rotary-drum vacuum filter. The vacuum filter removes the sludge from solution and discharges a clarified solution, free from suspended solids, to the sewer. The suspended solids collected on the vacuum filter are eventually removed to a dry dump.

While the contents of the first settling tank go through this sequence, the second settling tank is filled with solution from the mixing tanks. Then, the process is repeated for the second settling tank.

WASTE-TREATMENT OPERATIONS

Operation	Control Factors				
	Time	Rate	Concentration	Volume	Conductivity
Service		H	C	S	A
Product Rinse	S	H		C	
Backwash	C	HC			
Regenerant Introduction	C	H	C	C	
Slow Rinse	S	H		C	
Fast Rinse	A	H		C	S

H—Hydraulic Control
C—Critical Control
S—Secondary Control
A—Alternate to Secondary Control

6. Numerically Controlled Belgian Lathe

R. BINGEN, A. LEGLISE and J. VROMAN
A. C. E. C. (Charleroi, Belgium)

Although the lathe is considered as a sound prospect for recorded-information controls, most applications to-date in the metalworking field have been made to milling, boring, and drilling machines. Of considerable interest, therefore, is the recent demonstration of a numerically controlled lathe for stepped and conical parts. The prototype machine, Figure 1, was developed under the sponsorship of the Belgian IRSIA*. Operated by punched-tape controls, the machine features accuracies of plus or minus 0.0004 in. (positioning) and 1 min (conical slope).

* Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture.

Thirteen control loops control X and Y positions, maintain constant cutting speed at one of 10 discrete values, and adjust tail stock position. The numerically controlled equipment consists of three main units: the encoder console, the control cubicle, and the lathe itself.

In the encoding stage, Figure 2, a 32-channel punched tape is prepared for each type of part. Information on the required tool movement, feed rates, depth of cut, cutting speed, and slope of cone are taken from the part drawing and fed into the encoding equipment via a key punch. Tool movement in each axis is specified as a displacement (rather than an absolute measurement from a datum point) to a resolution of 0.01 mm. To facilitate tape preparation, digital readout counters display the actual tool position at each step.

Information on the 4¾ in.-wide plastic-coated paper tape is in binary-coded decimal form to accommodate a total of 180 different instructions. Within the encoder, matrix circuits incorporating selenium rectifiers and relays translate the input data into code signals. Checking circuits detect errors in the input commands and in the displacement signals.

Figure 3 shows examples of punching configurations for two different operations. The first represents a machining operation calling for the displacement of the longitudinal carriage towards the spindle by 324.25 mm with a tool feed of 0.8 mm per rev.

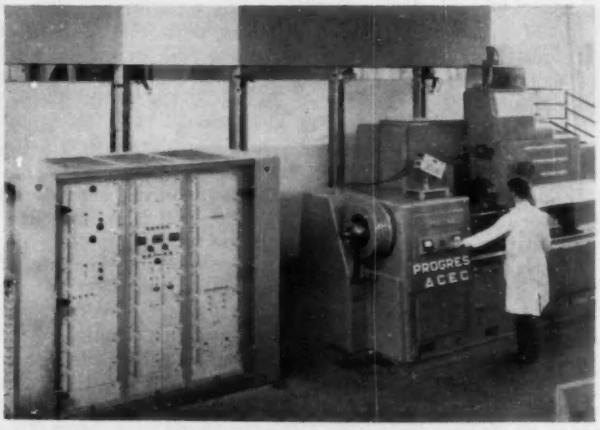
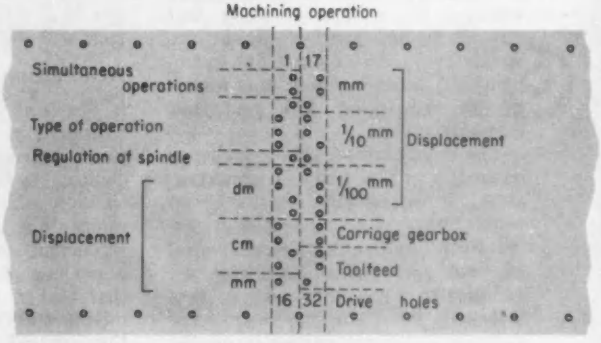


FIG. 1. Numerically controlled lathe, shown here at the Brussels Worlds Fair, has three main units: machine, control console, and encoder.

FIG. 2. Desk-type encoder features digital readout of the matrix circuits, giving actual tool positions as the operator punches in each new displacement.





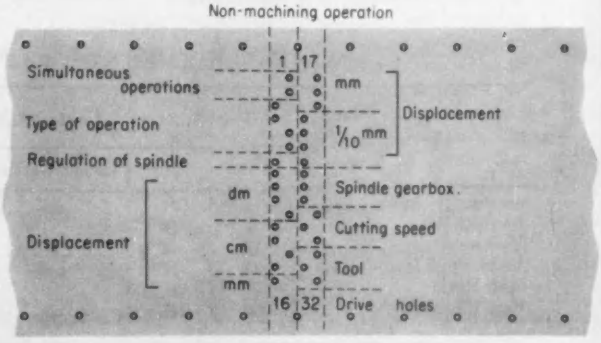


FIG. 3. Examples of programming codes used for machining and nonmachining operations.

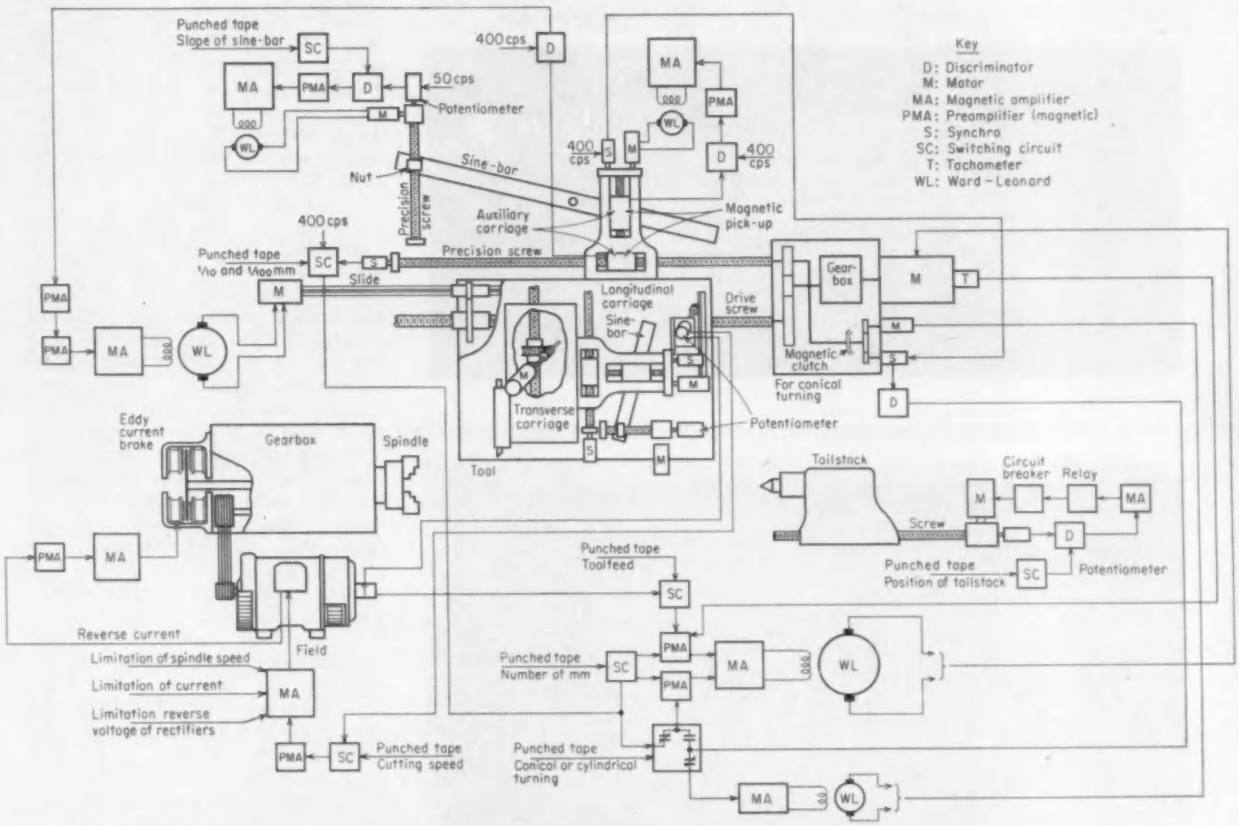


FIG. 4. General schematic diagram shows the control loops for feed rate, positioning tailstock position and conical-turning slope ratio.

The second is a nonmachining operation that consists of the chucking of the part that is to be turned, positioning of the tailstock at 125 mm from the stop, choice of tool number 6, choice of a one-to-one reduction ratio for the spindle gearbox, and the selection of a surface cutting speed of 320 meters/min.

The control cubicle contains the tape reader and the decoder, which uses ferrite cores and diode matrices to produce 100 binary output signals from the 32 tape channels. The memory cores have three inputs and one bistable output. Signals from the coding channels numbered 3 through 6 inhibit the memories to give various interpretations to the command signals from the channels numbered 8 through 32. Thus, certain channels may be assigned to several different control functions, effectively extending the capacity of the tape for handling the total of 180 instructions.

Machine servos

Figure 4 is a general schematic of the 13 different servo loops needed to control the speed and position of the spindle, the two carriage positions, the tailstock, and the angle of conical turning. Ward Leonard sets with 400-cps magnetic-amplifier regulators supply power to the separate 3-hp motors used to drive the longitudinal and transverse carriages. Figures 5 and 6 show the longitudinal positioning system. A similar system is used on the transverse carriage. The desired tool feed is maintained by accurate speed control of the carriage motors. The carriage is driven through a leadscrew and a gear box by an adjustable-speed dc motor. The velocity of the carriage is measured by a dc tachometer. Position feedback signals are provided by a 400-cycle synchro transformer.

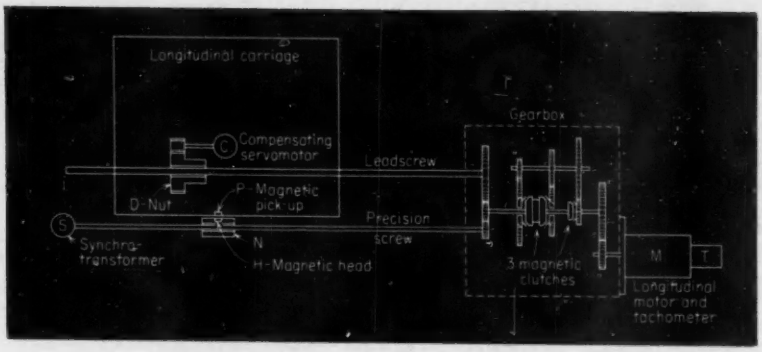
The synchro transformer, Figure 7, is of a special type with three rotor windings used as the primary, and five stator windings. Only two nonadjacent stator windings are used as the secondary; the three remaining are disconnected. A 1-mm displacement of the carriage corresponds to one-half revolution of the synchro transformer.

To achieve positional accuracy of plus or minus 0.0004 in. with rapid positioning (within 0.3 sec), the motion of the carriage is controlled by two different servos having 400-cycle push-pull magnetic amplifiers. The two loops consist of the following:

1–A speed control servo (tachometer, velocity preamplifier, main amplifier, dc generator and motor).
2–A position control servo (synchro transformer, position preamplifier, main amplifier, dc generator and motor).

Because at all times one of the two preamplifiers is cut off, the two loops never operate simultaneously. The displacements of the carriages are divided in millimeters and fractions of a millimeter. A special method of feeding the stator and the rotor windings of the synchro transformer permits control of the fractional part of the millimeter readings. If, in Figure 7, rotor winding Q is connected to centertap T of synchro winding S-U, the signal voltages across the stator windings OA, OB, OC, OD, and OE will each show a phase difference of 72 deg, when the carriage is traveling from one position to another. If the output is taken successively at the stator terminals AC, DA, BD, EB, etc., there are obtained 10 voltages that null at 10 different positions of the carriage, each separated by 0.2 mm.

FIG. 5. Arrangement of longitudinal carriage drive showing backlash compensation system.



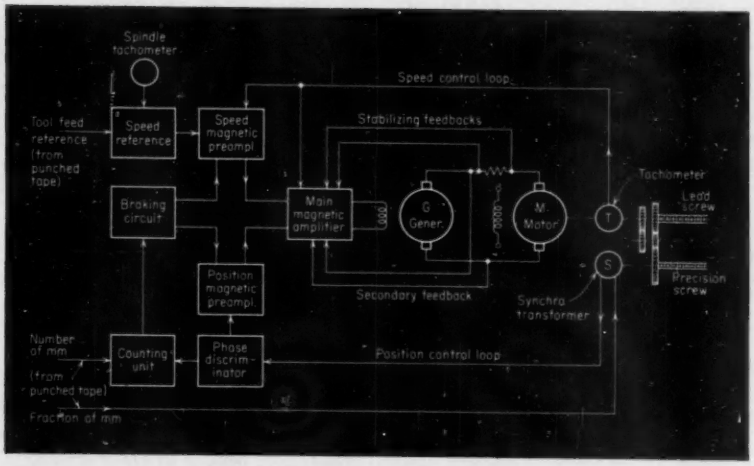


FIG. 6. Simplified schematic of carriage position and speed control.

Instead of being connected to the centertap of synchro winding *S-U*, rotor winding *Q* may be coupled to one of 20 other taps provided on either side of *T* (*T'*, for instance). Then the zero-voltage position of the carriage corresponding to two given output terminals (say *BD*) will be slightly offset from its former zero-voltage position. By properly choosing the voltages of the 20 taps of *SU*, it is possible to interpolate exactly to 1/20. Thus 200 distinct zeros occur for each revolution of the synchro, dividing each 1-mm movement of the carriage into a hundred steps of 0.01 mm each.

Three digital counting units determine the whole number of millimeters, by counting the number of half-revolutions of the synchro transformer. The counter has a capacity of 1,000 digits, corresponding to a maximum displacement of 800 mm of the longitudinal carriage. Before starting any displacement of the carriage, the counting unit is preset at 1,000 minus the number of millimeters of the desired displacement. After the counter has been preset, the carriage is started.

During the major part of carriage movement, the speed-control loop gives the desired tool feed and the position-control servo is cut off. When the carriage arrives at 1 mm from the desired position (as indicated by a 999 count), a special braking control circuit is triggered. This circuit changes the servo loop over from speed control to position control by saturating the speed preamplifier for rapid switchover. From this instant, the drive motor is controlled by the control transformer, which is at 180 deg from its equilibrium position. The motor and carriage stop at the succeeding zero of the synchro output, which is effectively a stable zero.

To overcome backlash, wear and manufacturing inaccuracies in the gears and the leadscrews, a subsidiary servo loop continuously corrects the relative position of the carriage with respect to its reference. The 3-hp drive motor simultaneously drives the main leadscrew and a second precision leadscrew, which displaces only a small nut. The precision screw moves both the synchro transformer used in the position control loop, plus magnetic head *H*, which is fixed to the small backlash-free nut *N*. A magnetic pickup is rigidly fixed to the main carriage, just in front of the magnetic head. Any difference between the desired position of the carriage (given by the precision screw and the magnetic head) and its actual position (given by magnetic pickup *P*) is detected, amplified, and used to actuate the separate compensating servomotor *C*. This turns the floating nut *D* mounted on the carriage sufficiently to take up the backlash and the play from other sources.

Once the carriage has reached its normal speed, the compensating servo reduces the static and dynamic error due to backlash and wear to less than 0.01 mm throughout the travel. The maximum transient error is only 0.05 mm, even when the carriage starts from zero.

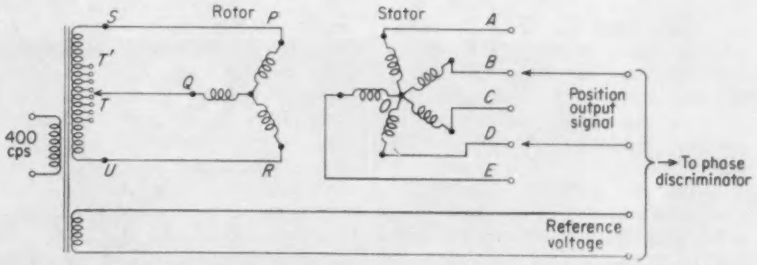


FIG. 7. Synchro-transformer with five stator windings to allow decimal positioning control.

Conical turning

For conical turning, the simultaneous automatic drive of the two carriages requires a large number of control circuits that can be justified only if the accuracy is high enough to produce finished parts requiring no further machining, except per-

haps grinding. This objective has been achieved by controlling the lathe to an accuracy of plus or minus 1 min on the slope of the cone, and an overall accuracy of plus or minus 0.03 mm (0.001 in.) on the diameter. For practical reasons, the maximum slope of the cones has been limited to 9 deg, to cover the range from 0 to 9 deg, or 81 to 90 deg.

A 3-ft long sine bar, Figures 8 and 9, is fitted to the lathe bed. As the bar turns about its center, its slope with reference to the axis of the part determines the slope of the cone. This slope (expressed in mm/m or in percent) is measured by a high-precision potentiometer mounted on a precision screw, which is driven by means of a servo, accurate to plus or minus 0.1 percent. Operation of this servo is controlled by information on the punched tape.

A small auxiliary carriage is mounted at the back of the longitudinal carriage. A magnetic pickup causes the auxiliary carriage to accurately follow the sine bar, as a small servomotor moves in the transverse direction.

Thus, for a given slope of the sine bar, say 3.25 percent, the auxiliary carriage is displaced by 3.25 mm for each 100 mm of travel of the main longitudinal carriage. When turning a cone of this slope, the position preamplifier of the transverse servo is switched from the synchro transformer on the transverse leadscrew to a synchro transformer mounted on the auxiliary carriage drive. In this way, the transverse carriage at each instant follows the displacements of the auxiliary carriage, with the result that the tool travels along the generator of a cone having the desired slope.

Although this arrangement is rather complex and requires a large number of synchros and servomotors, it provides a high accuracy and makes use of a simple coding process.

Spindle-motor control

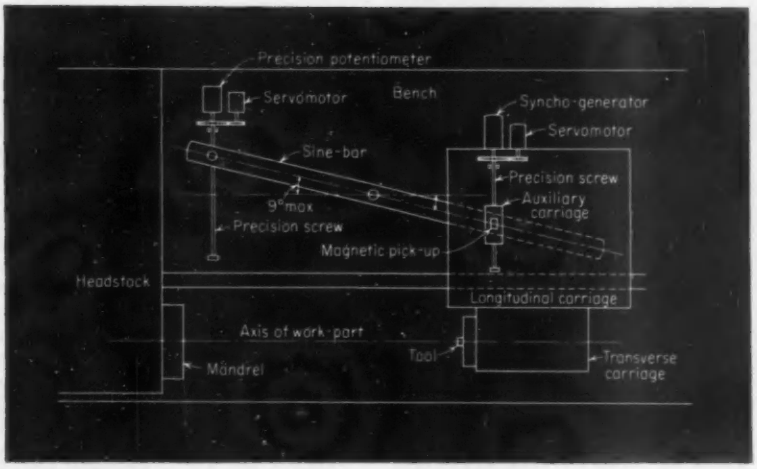
The 40-hp spindle motor is supplied with dc voltage obtained from a three-phase-bridge selenium rectifier (200 volts, 170 amp). Motor speed is varied from 1,000 to 3,000 rpm by varying field current, which is supplied by a 1.2-kw magnetic amplifier.

The spindle is driven through a gearbox having eight possible combinations controlled by the punched tape to yield speeds from 133 to 2,000 rpm. Cutting speed is regulated by a tachometer giving a voltage proportional to the angular velocity of the spindle. This voltage is fed to a potentiometer whose sliding contact is determined by the position of the transverse carriage. When the tool is at zero diameter, the slide is at one end of the potentiometer and output voltage is zero. With the tool at its maximum diameter, the output voltage is proportional to the product of the spindle velocity times the radius; that is, it is proportional to the actual cutting speed.

This measure of the cutting speed is compared with the desired value given by the punched tape. Any error signal is amplified by a magnetic preamplifier and the main-field amplifier to reset the cutting speed to the correct value.

As the diameter of the turned surface decreases, the spindle speed is automatically increased to maintain constant cutting speed. Because the motor is fed from rectifiers, it can provide no dynamic braking effect for the spindle. Braking is done by an eddy current brake, mounted on the shaft of the spindle and developing nearly 100 hp at 2,000 rpm. If the transient cutting speed remains at an unsafe level even after spindle speed is reduced, the control circuits switch to the transverse tool feed, and automatically reduce feed rate to the appropriate value.

FIG. 8. Top view of lathe bench shows the sine bar used in conical turning.



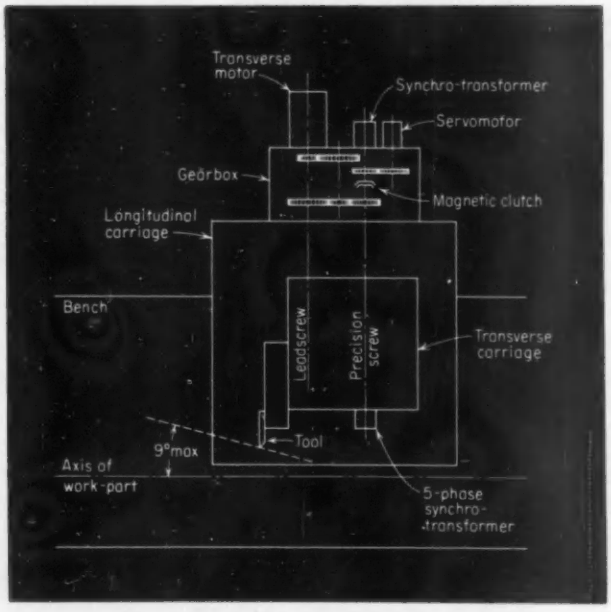


FIG. 9. Front view of carriages shows follow-up arrangement for generating conical surfaces.

7. Punched-Tape Circuit Analyzer

H. J. KIRSCHNICK and B. D. HRYBYK, Westinghouse Electric Corp.

Because of the complex circuitry involved, military electronic gear poses special problems for the production test department. Manual circuit checking is tedious, costly, time-consuming, and fraught with the possibility of human error. Automatic test techniques have been employed, but require the use of special "adapter" equipment between the product being checked and the test instrumentation. The adapter equipment is expensive and is normally designed for a single product run. Hence, automatic testing has been limited principally to cases where large numbers of a single type of unit is in production.

The Automatic Circuit Analyzing Device (ACAD), Figure 1, has been developed at the Westinghouse Electronics Plant in Baltimore to make automatic testing practical for one-of-a-kind units as well as for those being built in quantity. ACAD is a punched-tape-programmed machine that automatically checks continuity, dielectric strength up to 500 megohms, dc resistance, ac impedance at any frequency up to 20 kc, and dc and audio-frequency voltages up to 500 volts. The unit is adapted to automatically test a piece of electronic equipment simply by inserting the test tape prepared for that equipment.

The ACAD consists of three main sections. The first is an input panel carrying a total of 27 nine-pin and 10 24-pin connectors. Cables from the product under test are plugged into this panel. Adjacent to the input panel is a test point panel containing 483 jacks, each connected to an input pin. This panel is provided for manual access to any of the test points or for the connection of auxiliary instruments or equipment.

A second major section of the machine is a CTI Supertester, equipped with six bridges for measurement, a bridge balance detector and output relays, Figure 2. Whenever a measurement indicates a satisfactory condition, the go relay is energized to advance the input tape to the next step. If the reading is outside limits, the no-go relay lights a red signal lamp and also advances the reader. An automatic printer makes notes of the fault for later repair.

A frequent method of test for all parameters except continuity and leakage is the "over and under" no-go scheme whereby each component is given two tests. In the first case the bridge is set on the high side of the allowable tolerance for a parameter such as voltage. The polarity-sensitive null amplifier should then indicate a fault on the low side. In the second test, the bridge is set to the low end of the tolerance and the amplifier should indicate a fault on the high side. A phase-reversing relay in the output of the amplifier is energized every other step. Thus, if the polarity of the output remains the same for both tests, the circuit is acceptable.

The third major section is the program controller, featuring an 85-channel punched-plastic tape unit, Figure 1, manufactured by Industrial Timer Corp. Each line on the tape contains information for one measurement in the test cycle. Certain channels on each line set up the test-point selection cross-bars, each with 483 wires in, one wire out. Two crossbars are required, one to select each end of the component to be tested. Other channels of the tape choose the one bridge of the analyzer that is to be used for that particular test. Fifteen channels of the tape are punched in 1-2-4-7 code and assigned to the limit selector circuit, which establishes the value of resistance that is to be applied to the reference leg of the bridge. The limit selector circuit consists of a relay matrix by which combinations of resistors ranging from 1 ohm to 700 kilohms are established.

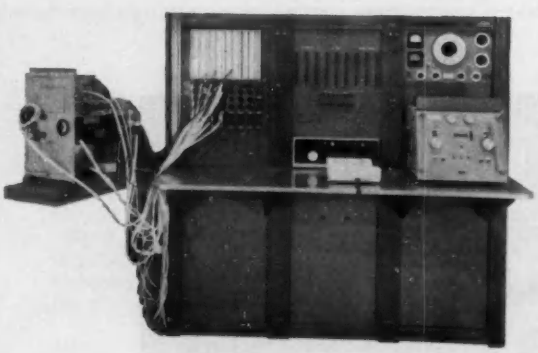


FIG. 1. Three consoles make up circuit analyzing machine. Unit under test is shown at the left.

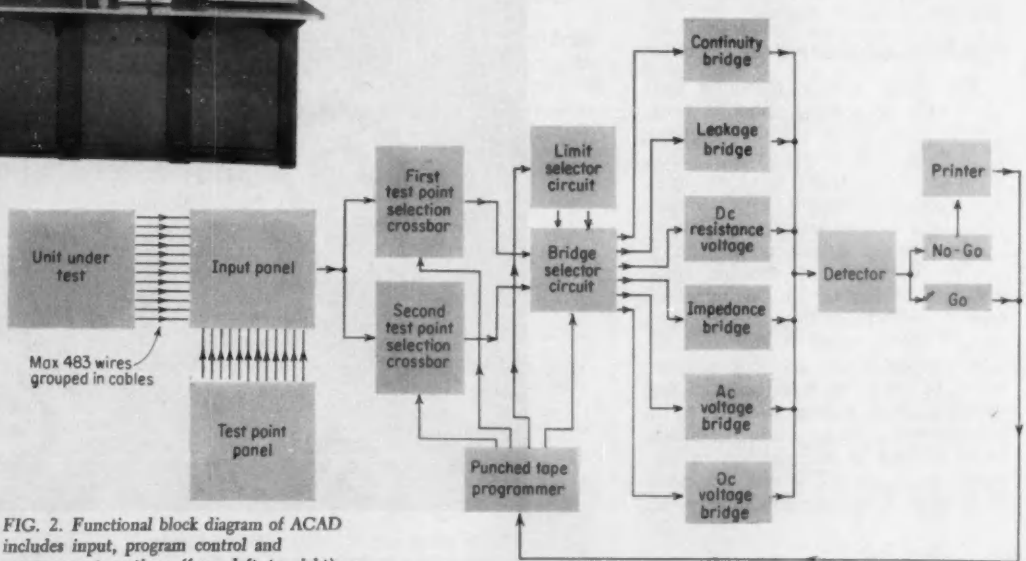


FIG. 2. Functional block diagram of ACAD includes input, program control and measurement sections (from left to right).

8. Package Dyeing System for Textiles

LESLIE H. VAN HUBEN, Taylor Instrument Cos.

In the normal course of textile dyeshop operations, product and color are constantly being changed. This means that for best results, certain process variables must be changed also to suit the particular combination of yarn and dyestuff in work. For the dyeing industry, therefore, program control has distinct advantages. Flexible time-based controllers for temperature and flow direction, for example, make it possible to quickly adapt package-dyeing equipment to innumerable varieties of yarns and dyestuffs.

Package dyeing refers to a method of dyeing yarn (or thread) which has been wound on perforated tubes and then loaded into a closed vessel. The complete dyeing equipment, Figure 1, also includes an "addition" tank, a pump and a circulating system. This unit is so designed that dye liquor may be pumped into the center of the perforated tube, then circulated through the layers of yarn and back to the pump. Flow in this direction is termed "inside-out". A four-way valve is included to provide a counter, or "outside-in", flow. In addition, means are provided for steam heating the dye liquor.

The dyer is faced with the problem of having to change the program, possibly several times a day. Thus, his need is for a flexible program controller, and, because one loading of the machine represents several hundreds of dollars, this controller must be repeatedly accurate. If the product is off-shade or uneven, the only chance of reclamation is to redye the batch in a darker shade or color.

Time-temperature control

Each particular dyestuff generally reacts at maximum efficiency only within a certain temperature range. Time of exposure is also a critical variable because at a given temperature an increase in time will increase the amount of dye deposited and will deepen the shade.

One device specifically designed for this application is basically a cam-operated temperature controller, Figure 2. The normal package-dye temperature cycle involves a controlled rise to a holding temperature, followed possibly by a controlled cooling.

When the start button is pushed, the instrument immediately takes over, illuminating a green signal light and bringing the process to a preset temperature for a short stabilization period. Following this period, the cam drives the setpointer upward at the desired rate. The rate of rise is controlled by the rate timer, which drives the cam by intermittent pulses of current. When the hold temperature is reached, a red signal lamp lights, the cam stops, and the hold timer is energized. The controller then holds the temperature constant during the hold period. At the end of the holding period, the instrument turns out the red light and shuts off the steam to the heat exchanger.

Usually at this point a signal light or horn calls the operator to check the shade and adjust the dye liquor if necessary. A decision is made also on whether to continue the dyeing or complete the cycle. If it is to be continued, the hold timer is adjusted to the "add" time desired and the programming instrument immediately turns on the steam. When the temperature reaches the hold value, the timer starts. At the end of the add period, the instrument again cuts off the steam. The add cycle may be repeated as often as desired, although once or twice is normally sufficient.

At the end of the final-add period, the operator initiates controlled cooling by readjusting the rate timer and depressing the "cooling" button. The program cam rotates in the reverse direction, driving the setpointer downward at the rate determined by the rate timer. At the same time, the instrument turns on a white light, closes the steam valve, and throttles a cooling water valve. At the end of the cooling cycle, the instrument closes the water valve and turns off the white and green lights. The dyeing cycle is then complete.

Programmed flow reversal

Because the dye tends to deposit on the first bit of yarn with which the liquor comes in contact, it is necessary to periodically reverse the direction of flow if a level shade is to be attained throughout the yarn. The program for this reversal is independent of the temperature control described above. The reversal programmer, consisting of two adjustable reset timers operating in conjunction with electrical relays and solenoid air valves, controls the four-way valve, which may be operated electrically or pneumatically. Two timers are needed because the resistance to flow is not the same in both directions; i.e., flow rates differ and timing of the flow in each direction must be independently adjustable.

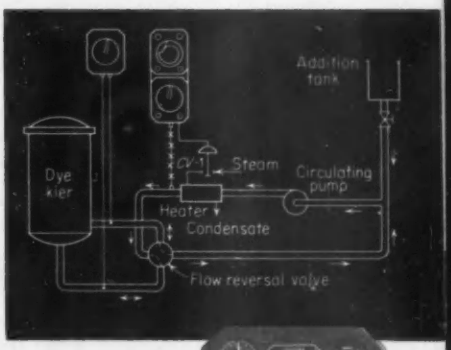


FIG. 1. Schematic of a package dye machine. Not shown are the reversal timers which operate an electric motor to reposition the reversal valve.

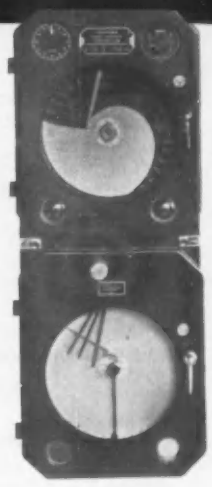


FIG. 2. Cam-operated time-based temperature programmer.

The timers are interlocked with the temperature controller to insure simultaneous starting and that whenever the cycle is stopped the four-way valve will be positioned for outside-in flow. The reason is that at the beginning of the cycle, the packages offer greater resistance to flow and considerable pressure differential can occur across the packages. If this differential becomes too great, it may "blow" a hole in a package by breaking the yarn and not only ruin the package but endanger the entire load. This danger is less in outside-in flow because the yarn has the support of the tube upon which it is wound.

9. High-Speed Continuity Checker

WILLIAM D. BELL, Mellonics, Tucson, Arizona

An automatic circuit checker capable of making absolute continuity checks on large systems must be extremely fast and have great capacity. These requirements have limited continuity checkers in the past to the verification of positive conditions only; that is, the checking of a circuit from, say, *A* to *B*. In an absolute check, *A* must be tested also against *C*, *D*, *E*, *F*, and all other terminals to make certain that no incorrect conditions or shorts exist.

The Mellonics Circuit Checker has been designed especially with the speed and capacity needed for absolute continuity checks. It is intended only for such checks; there are no provisions for measuring impedance, voltage, or current.

The problem of making an absolute check is more difficult than it appears at first glance. In a wiring array with 2,500 terminals, terminal *A* must be checked against 2,499 points, terminal *B* against 2,498 points, terminal *C* against 2,497 points, etc. The total number of circuit combinations is given by:

$$T_{cc} = \frac{n(n+1) - 2n}{2}$$

For $n = 2{,}500$, there are 3,123,750 combinations; with 3,600 terminals, the total number of circuit combinations is over 5 million.

To cope with these requirements, the Mellonics equipment operates at a maximum scanning speed of 60,000 circuit combinations per min. If parallel pulsing of terminals in selected inputs can be tolerated (dependent upon test-circuit configuration), this speed may be made as high as 360,000 combinations per min, the exact figure being determined by detail specifications and the programming employed.

In addition to fast operation, the circuit checker provides these benefits:

1—Elimination of setup time, regardless of test-circuit configuration.
2—Elimination of response programming. The first correctly wired device encountered in a test run is used to store the pattern of pulses for checking subsequent similar devices at any later time.
3—Complete flexibility in the testing program to be followed. Both plug-in components and individual terminals can be programmed in any desired order.

Despite its sophisticated operational features, the checker is not complex. Simplicity is made possible by the use of IBM punched cards for programming the checker, generating the phase-referenced test pulses, and storing the pattern of correct response pulses. An IBM type 519 or type 514 reproducing punch is coupled to the circuit checker to read and punch cards, and to provide control and comparison circuitry. Thus, the circuit checker is essentially only a selector, with very minor control features. The real complication exists in the IBM punch (which can be leased) and in the card programming (which is readily set up).

To understand the operating principles of the circuit checker, it is necessary to understand the IBM reproducing punch, because this machine is the heart of the system. In a standard reproducing operation, punched cards are placed in the read hopper, and blank cards in the punch hopper. As cards are synchronously fed on both sides of the machine, the blank cards are punched in a pattern that depends upon the plugboard wiring. The basic punching circuit is shown once in Figure 1; it is actually repeated 80 times, for the 80 columns.

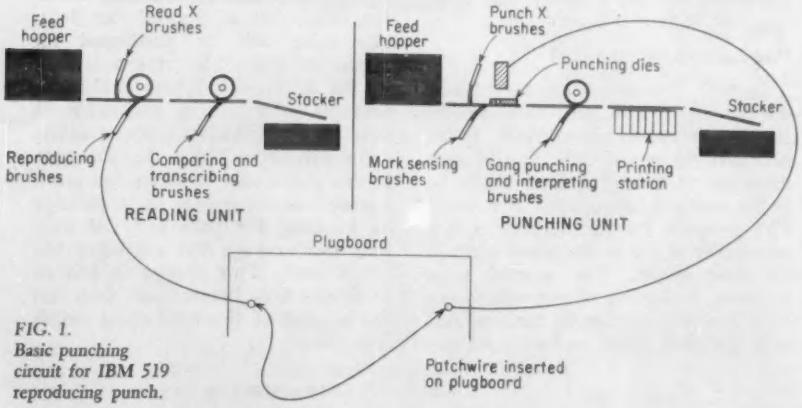


FIG. 1. Basic punching circuit for IBM 519 reproducing punch.

If the plugboard in Figure 1 is considered to be a "black box", it is obvious that a method is available for feeding parallel impulses, generated in an arbitrary pattern, into one side of this black box. Further, it is possible to take the parallel output pulses from the black box and record these pulses by punching into cards. This recorded pattern of output pulses is a unique function of two variables: (a) the hole-punching of the cards on the read side of the 519, and (b) the wiring inside the black box, which interconnects input and output. This is exactly how the circuit checker works; the only additional requirement is that means be provided to independently select the input and output plug-in components.

The routine for operation in the record mode is as follows:

1. A correctly wired test device is connected to the circuit checker with adapter cables.
2. A "master deck" of IBM punched cards is placed in the read hopper. These cards program the switching operations in the circuit checker and also supply test pulses in a prescribed pattern.
3. Blank cards are placed in the punch hopper.
4. The start button is pushed. At 100 cards per minute, the correct wiring pattern is recorded. Each card contains data for up to 600 circuit combinations between a pair of plug-in components.
5. These "answer cards" are stored, along with the master program deck, for later use.

While reproducing, the 519 can also compare the original and new cards, to verify that punching is correct. Within the 519 are 80 comparison circuits consisting of 80 solenoids, each with two opposite-polarity windings. Simultaneous pulses are canceled; a single pulse on either side

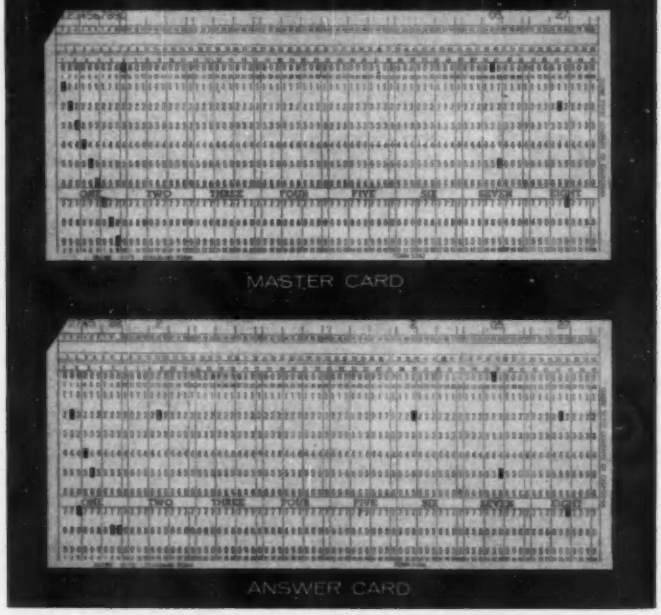


FIG. 3. Master card and the corresponding answer card that the circuit of Figure 2 would produce.

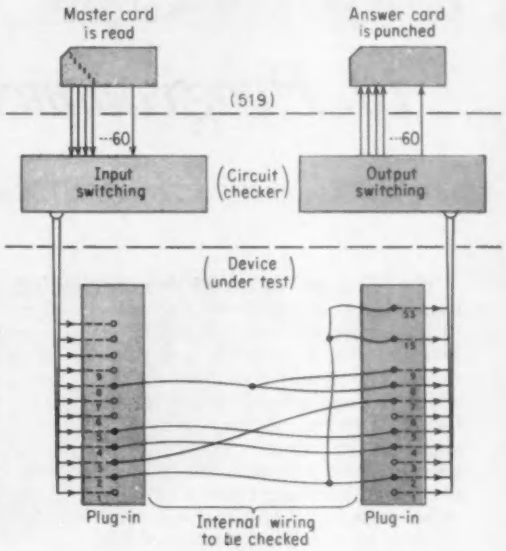


FIG. 2. Schematic diagram of a checking operation.

causes an error stop. The circuit checker uses exactly these same circuits to compare the pulses put through an unchecked device with the correct wiring pattern, previously recorded in an "answer deck".

The routine for operation in the comparison mode is as follows:

1. The device to be checked is connected to the circuit checker, using adapter cables.
2. A master program deck and the previously prepared answer deck are selected and put in the feed hoppers of the 519.
3. Operation is started. Comparison proceeds at 100 cards per min.
4. If an error is detected, the 519 stops. The numbers of the two plug-ins between which the error exists are read from two digital lamp banks in the circuit checker. Further, the exact identification of the terminal numbers where the errors are located is read from the comparing indicator in the 519, which identifies the card columns that did not compare.

From the above, it is evident that the circuit checker can record its own data and also uniquely identify wiring errors even though terminals are tested in parallel. The card programming necessary to achieve these results is simple. It is necessary only to specify two numbers in each master program card to select two plug-in components. The checking of wiring between these selected components is accomplished by the pulse pattern punched into the IBM card, which activates input terminals in an arbitrary pattern.

Thus, each card in the master program deck contains two-digit input and output addresses which uniquely identify plug-in components. During each card cycle, two new addresses are read into the circuit checker and stored; simultaneously, the two plug-ins selected on the prior card cycle are tested. At the end of the card cycle, and as the next card begins to read, the switching circuitry automatically advances under control of the stored addresses to select new input-output plug-ins. If this switching requires more time than is available before the beginning of the test pulses, the 519 is programmed to stop and wait.

The test pulses can be any desired arrangement of serial, parallel, or series-parallel signals. Further, this pattern can be completely different for checking between different plug-ins. The pulse pattern depends only on the card punching in the master deck.

These operations are shown in Figure 2. Switching gear selects one plug-in for an input, another for output. As the card is read, the pulses go through the device under check and punch holes in another card.

Figure 3 shows a master card and the corresponding answer card that the wiring of Figure 2 would produce. Notice that the answer card can be read directly without reference to a wiring call-out sheet:

(a) The input address is plug-in number 5.
(b) The output address is plug-in number 27.
(c) Columns 2, 15, and 53 are punched with a "2". Therefore, terminal 2 of plug-in 05 is jumpered to terminals 2, 15, and 53 of plug-in 27.
(d) Similarly, terminal 3 goes to 7, 4 to 4, 5 to 5, and 8 to 8 and 9.

A simple punched-card procedure can be used to set up the master program decks. Usually, only a few general-purpose program decks are needed to check out a wide range of different specific equipment designs. Such programming decks can be made by an accounting department (if IBM equipment is available) or by an IBM service bureau, or can be furnished by the circuit-checker manufacturer.

It is difficult to be explicit about the method of setting up program decks. Essentially, the procedure consists of a series of keypunching, sorting, collating, and reproducing operations. The end result is a deck of cards with the proper sequence of addresses and test pulses for the desired checking operations. In any specific application, the approach taken depends on how the user wants the checking operation performed. So far as the checker is concerned, complete flexibility exists. Typically, one input is selected and held constant while successive outputs are scanned.

FIG. 4. Mellonics circuit checker is shown here being used to check out a Beckman data-system module.



10. Programmer for Mechanical Arm

JOHN M. GRAHAM, Graham & Associates

The "Planobot", Figure 1, is a mechanical arm designed for the automatic transfer of material and parts into and out of machines and processes. The motions of the device, which is manufactured by the Planet Corp., Lansing, Mich., are programmed by means of a bank of potentiometers with sufficient capacity to store an operating cycle of 45 individual steps for all four motions. The motions are as follows: rotation of the clamp at the end of the arm (wrist); extension of the arm (ram); raising and lowering the arm (tilt); and rotation about the vertical axis of the machine. The combination of arm movements permits the clamp to be shifted to any point in the area between two circles of 3½- and 6-ft radius. The tilt motion covers about 60 deg.

Figure 2 is a schematic block diagram of the program-control system. There are four positioning loops, one for each motion. The command signals are in the form of potentiometer voltages. Position feedback is supplied by multiturn potentiometers geared to the various drives. In the memory or "pot field", there are 45 groups of five potentiometers each. Four potentiometers in each group are assigned to position commands; the fifth is part of an RC timing network in the stepping-switch drive circuit. The function of the 45-position, six-level stepping switch is to connect each group of potentiometers in turn into the positioning loops.

Errors between input and feedback position signals are amplified by means of electronic amplifiers and relays, then used to energize valve solenoids. Rotary motions are powered by hydraulic motors, and the ram, tilt, and clamp operations by double-acting cylinders. The swing rapid traverse is about 90 deg per sec (about 10 ft per sec at full radius), while a slow speed of 3 in. per sec is used within 1½ in. of final location. The ram speed is 1 ft per sec.

To program the Planobot for a sequence of operations, the stepping switch is advanced one step at a time. The four position potentiometers associated with each step are adjusted as needed to move the clamp to the desired location. Then the stepping switch is placed on automatic operation and the arm will repeat the routine for as long as desired.

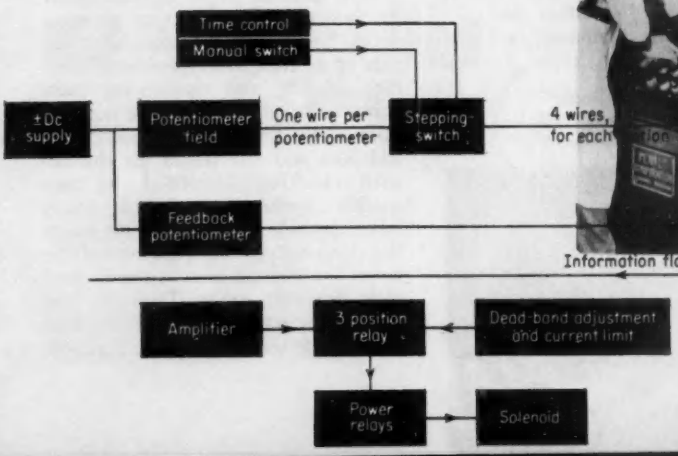
The time-delay potentiometers must also be adjusted for each step in the cycle. These potentiometers determine the period that the stepper will remain at one position before advancing automatically to the next. When the stepper is first placed on automatic operation, all timing potentiometers are adjusted for maximum delays. Then, as the machine goes through its cycle, the time allowed for each step is reduced to a length just sufficient for the prescribed motions.

The timers can also be adjusted to provide smooth, continuous arm movements. Consider, for example, an arm that is to withdraw a part from the machine and place it on the floor, and to one side. One step of the switch would provide for clamping. On the next step, the retract motion (ram) would start, with the ram position-potentiometer set for the full retraction. But the time-potentiometer (for that step) can be adjusted so that as soon as the clamp has cleared the machine, the stepper will advance, starting a swing while continuing the retract. Similarly, the succeeding timing potentiometer would be trimmed to start extension of the ram and a downward tilt, as soon as the swing had progressed far enough to provide the needed clearance. The stepper would probably then remain in this last position until all motions were completed. The result of such timer adjustments would be one continuous movement of the arm, rather than a series of disjointed steps.

FIG. 1. View of Planobot mechanical arm shows pushbutton station and hydraulic power supplies at the left.



FIG. 2. Block diagram of Planobot positioning loop for one motion of arm.



11. Card-Controlled Feed Mixing

J. F. SHARP, Lindars Automation, Ltd., Sheffield, England

Various formulas of grain-based animal foods are blended automatically under punched-card control at the Barkers, Lee & Smith feed mill at Beverly near Hull, England. The punched cards program the total weight of the batch as well as the proportions of its ingredients. The control system consists principally of telephone-type-relay and stepping-switch circuits.

The system selects from 24 blending bins and automatically weighs all the main ingredients of a 2-ton batch in 3 min. Weighing accuracy is better than 1 percent. A single operator controls the functioning of the mill from the main console, Figure 1, in which two control systems are incorporated. One controls the routing of the incoming grain from barge or truck unloaders to any one of 20 storage bins. The second system controls the process-plant conveyor system, which draws off material from the storage bins, passes it through grinders if required, and delivers the material to any one of the blending bins. The capacity of each blending bin is approximately 10 tons. The 24 blending bins are split into six groups of four. Each group feeds an automatic weigher with a maximum capacity for each discharge of 2 hundredweight (one-tenth ton).

For each mix, a 13 x 8 in. punched card is prepared, Figure 2. The horizontal rows of the card contain data that determines the weight of the ingredient required. A separate line is used for each bin. Weights in binary code are expressed in hundredweight units and 7-lb fractions.

When the start button is pressed, electromagnetic clamps operate to prevent the removal of the card until the sequence is complete. Each group of four lines on the card (corresponding to the four bins associated with each weigher) is scanned simultaneously by multiposition stepping relays, one line at a time. Each scanning relay scans the card until a punched hole in the hundredweight range is encountered. The hole position sets up stepping relays in the discharge counter, Figure 3, thus determining the number of discharges that the 2-hundredweight weigher will make before scanning continues.

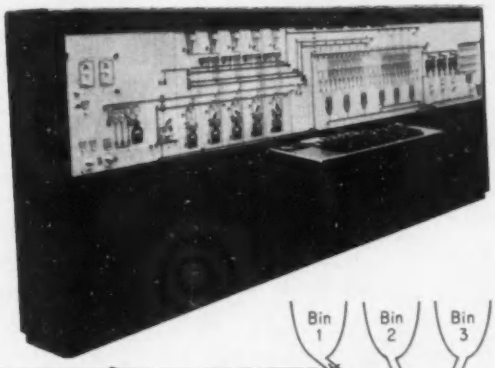


FIG. 1. Control center and display board in feed mill. Three card readers are on new line desk in front of panel

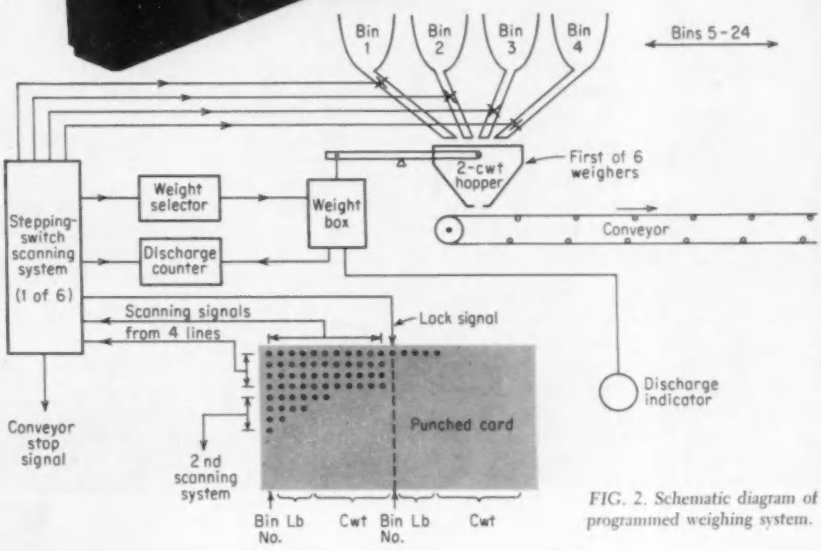


FIG. 2. Schematic diagram of programmed weighing system.

The feed gate of the appropriate bin is now opened, and material enters the weighing hopper. The weigher is a simple beam balance with the hopper on one end and adjustable weights on the other. As it approaches balance, the beam trips a limit switch to reduce the feed to a slow trickle. Uniform flow is achieved from the hopper by vibrating the feed-slide continuously between the open and closed positions. When final balance is reached, a second limit switch cuts off the feed completely and discharges the batch onto a conveyor. Each weighing operation counts down the stepping relay in the discharge counter one position, until the home position is reached. The hundredweights sequence is then complete.

The remaining holes, corresponding to fractions of a 2-hundredweight load (that is: 1 hundredweight, 7, 14, 28, and 56 lb), are then scanned by the main stepping relays. Information from these holes is stored on relays, then used to operate an electromechanical weight-selection system. The weight platform normally contains 15 separate balance weights that make a total of 224 lb. These weights can be removed by a selector platform, which is mounted above the weight platform and can be raised or lowered. The platform contains electromagnetically operated hooks that engage loops on the individual weights.

When the information in the last five holes in a particular line is read, the selector platform is lowered. Relays corresponding to the weights that are to be removed are energized. When the platform is raised, the unwanted weights are lifted clear.

12. Testing Inertial-Guidance Computers

CARL PILNICK, Consolidated Avionics Corp.

Now being readied for tests in the United States is a missile of the ICBM variety that employs a sophisticated inertial-guidance control. Part of the system loop is a missile-borne digital computer that will accept frequency signals denoting the missile flight conditions (yaw, pitch, velocity, etc.). The computer will examine this information to determine if the flight is proceeding according to plan, and then transmit any corrective signals needed to maintain the missile on the prescribed trajectory.

To insure proper performance of the computer (vital, of course, to satisfactory operation of the missile) equipment has been developed for automatic production checks and preflight testing. The tester, Figure 1, provides a simulated problem for the computer, monitors its operation, and records computation results and pertinent test data in both digital and analog form. The computer is a digital type designed for serial transfer and operation; it uses the binary code, and performs the arithmetic operations of addition, subtraction, multiplication and sign determination.

Operation of the tester is under the control of a perforated paper tape, upon which has been prepunched codes that determine both the type of signals transmitted to the computer and the time duration of those signals. Each block of tape data is translated into six frequencies, and voltages varying at these frequencies are used as computer inputs. Timing codes on the tape simultaneously preset counters so that at the end of the desired time interval, the input problem frequencies are automatically switched to conform to the data on the next tape block. This process is repeated until all problems on the perforated tape have been completed.

During the test run, the computer sends back to the tester the computation results in the form of a servo error signal output and two timing pulse signals. The pulse signals stop the operation of counters in the tester, and the final count, plus test number data, is then printed out by a digital printer. The count so printed will be compared against expected known values that will result if the computer has correctly performed its calculations. Pertinent test voltages and waveforms are simultaneously plotted by an oscillographic recorder.

Since the computer application is so critical, accuracy and reliability of the tester are of paramount importance. Redundant circuitry is provided for all critical sections of the tester. Error detectors that indicate and record all tester errors form an inherent part of the equipment design.

There are three racks of equipment in the tester. The center rack contains the tape reader and programming controls, the error indicators, program storage relays, problem frequency generator, preset counters, and timebase circuitry. The right-hand rack consists of the special-purpose oscillographic recorder and the relay power supply, while the left-hand rack includes the frequency counters, the printer, and power control units.

A block diagram of the tester is shown in Figure 2. The tape reader is a Soroban unit programmed to read 11 rows of data at a time. Two relay stores are provided to permit the reading of one tape block, while the information in the previous block is being transferred into the circuits. The function of the binary rate multiplier is to supply information in the form of pulses per unit of time to the computer. The source of the pulses is a constant-frequency oscillator. Certain of the pulses generated are passed or blocked by means of gating matrices that are set from tape data.

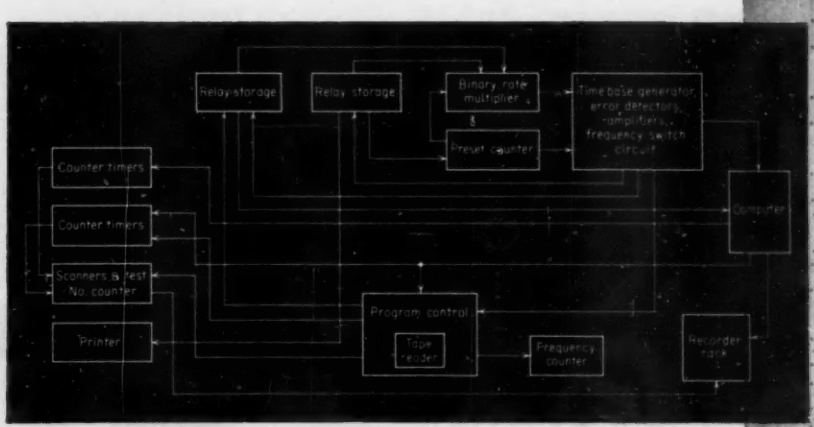


FIG. 2. Block diagram of computer tester, consisting basically of source of pulses, a means of gating prescribed numbers of these pulses into the computer, and counting units to record the numbers of pulses entering and leaving the computer.

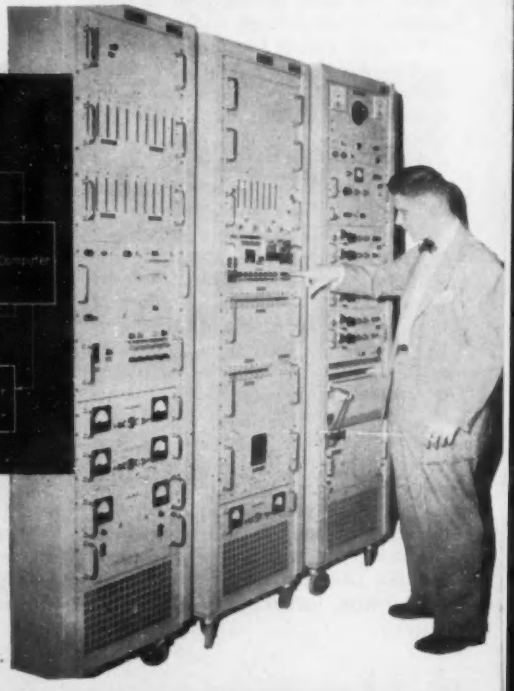
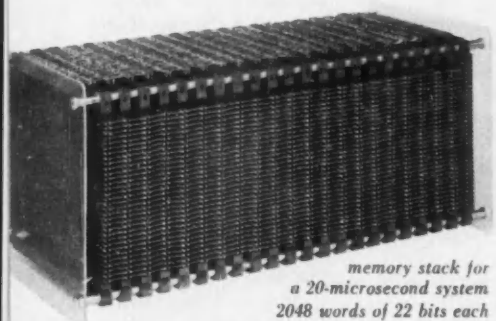


FIG. 1. Tester for checkout of missile inertial-guidance computer includes three main racks of equipment.



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memory stack for
a 20-microsecond system
2048 words of 22 bits each

Because TELEMETER MAGNETICS manufactures the memory system complete from core production through array wiring to finished units . . . and because TELEMETER MAGNETICS tests each phase of production thoroughly . . . you can be that much surer when you specify memory systems designed and engineered by TMI.

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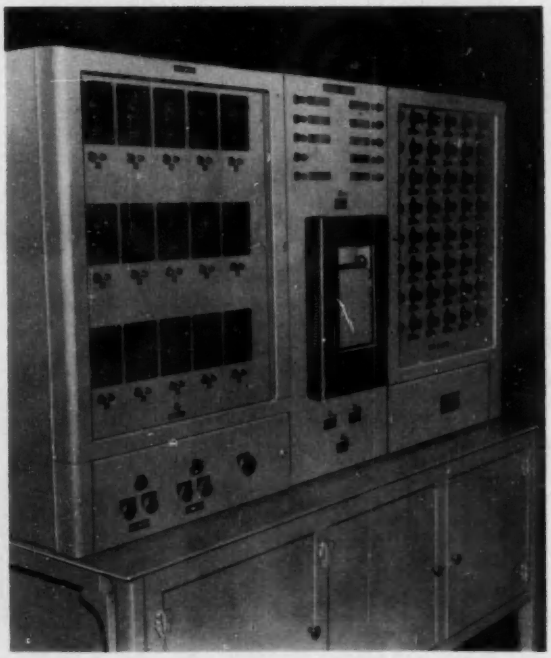
ORTANT JOB OPPORTUNITIES

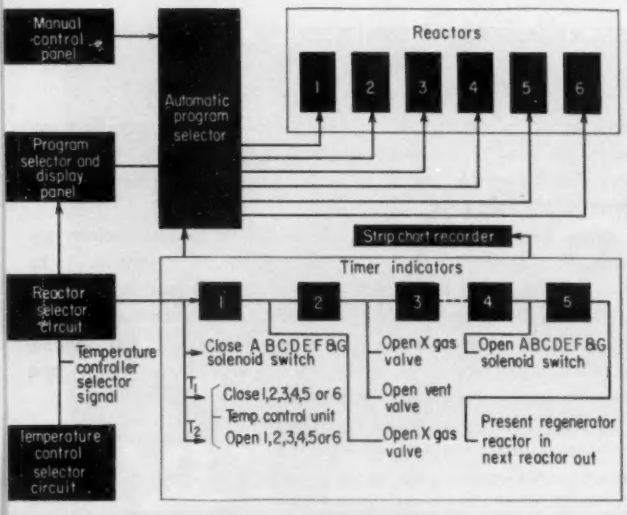
nsion to handle our increasing business activity plus research and develop- in new areas have created openings for qualified computer engineers. tigate the wonderful opportunities offered by TMI in Southern California

NEW PRODUCTS

LISTING IN GROUPS

Designs of the Month
Data Handling & Display
Primary Elements & Transducers
Controllers, Switches & Relays
Power Supplies
Actuators & Final Control Elements
Research, Test & Development
Component Parts
Accessories & Materials





NEW SYSTEM programs 720 events.

Already in operation at Esso Research Laboratories, Linden, N. J., this new programming and recording unit will automatically time and monitor as many as 720 sequential events in a discontinuous or batch process. In the application at Linden, it controls the cycling of reactors for catalyst regeneration in a pilot gasoline plant.

Photo and block diagram at the left illustrate the system as installed. Panels shown on the desk-top cabinet are as follows: program selector and display panel, timer panel, power and danger panel, and a center panel that includes the strip-chart recorder and miscellaneous circuits.

Forty-eight seven-position selector switches on the program selector panel provide for 48 complete cycles of catalyst regeneration. During each cycle, any one of six reactors can be selected for regeneration. The seventh or "zero" position indicates that no reactor is programmed for that particular cycle and the unit automatically skips to the next cycle. A lamp under each selector switch indicates the current cycle number of the program. A stepping-relay circuit provides the sequential cycle action. The manual control panel permits the operator to override the program at any time.

Fifteen time delays occur during each cycle. Control operations may be carried out at the beginning and end of each delay. Relay-type controls, used throughout, create a reliable and rugged industrial control environment. An indicator light adjacent to each electromechanical timer shows the time delay currently in effect; an override button on each performs all the operations that would have been performed had the timer been allowed to complete its cycle. This includes starting of the next timer.

Should a power failure occur, the unit automatically removes power from all local circuits, reduces reactor temperature settings, and freezes timer motors and solenoid valves in their present position to permit restarting at the same point in the program.

Facilities are provided for monitoring up to 10 external circuits. In the Linden installation these represent the most probable sources of failure. Failure of any one or a combination of these 10 circuits is displayed and the emergencies identified by visual and audible alarms.

The strip-chart recorder on the center panel provides a complete record of events that occur during unattended operation. At Linden, a record of only five distinct timer events is adequate.

Since pilot production of gasoline results in an output it is convenient to have this product flow to two barrels on an alternate basis. The Linden unit, therefore, includes a cam-operated motor-driven circuit that switches product flow every 30 min.—Devcon, Inc., Plainfield, N. J.

Circle No. 200 on reply card

BALL VALVE uses explosive pilot.

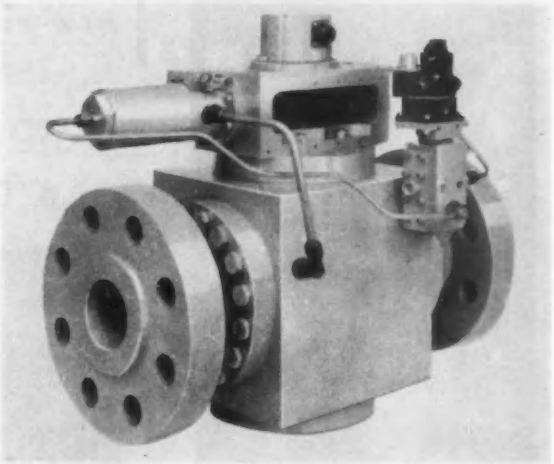


Photo at the right shows a pressure-operated ball-type valve capable of fully opening or closing a 3-in. line in 7 msec, against liquid or gas pressures as high as 4,000 psi and temperatures to 250 deg F.

A built-in high-pressure air accumulator controlled by an integral explosive pilot valve provides this fast operation. Set off by a low-amperage electrical impulse, the pilot valve opens the accumulator, permitting air to drive the main valve by means of a pneumatic cylinder. A built-in, motor-operated four-way valve simplifies recharging of the accumulator and recycles the actuating cylinder.

Unit should find applications in chemical process installations, oil-well capping control, high-pressure steam lines, missile-fueling systems, and wherever else fast, precise flow control is important.–Hydromatics, Inc., Livingston, N. J.

Circle No. 201 on reply card

COLOR ANALYZER suits lab or shop jobs.



The addition of a reflectance attachment to a Spectronic "20" Spectrophotometer provides a color analysis instrument that permits extremely accurate readings in percent reflectance of paints, textiles, inks, dyes, glass, and a variety of other products. Design features include a pivoted aperture cover that allows handling of larger samples, a trichromatic chart for rapid conversion of reflectance readings to standard CIE values, and a true spherical integrator that assures high accuracy in color analysis and color matching applications.

Fading, chipping, and staining of the sphere's interior surface has no effect on reading accuracy. Use of a precision diffraction grating provides light of high spectral density and eliminates the need for glass filters.

A specially developed power supply for positive voltage regulation operates without fluctuation on a 50- or 60-cycle supply.

Complete analyzer costs $515; attachment alone, $280.–Bausch & Lomb Optical Co., Rochester, N. Y.

Circle No. 202 on reply card



TAPE READER handles 5- to 8-level codes.

Shown is the first commercially available paper tape reader to operate at a rate of 1,000 characters per sec. Photoelectrically, the unit reads paper tape information into control and computer systems requiring programmed data. Despite its rapid reading rate, it will stop on a single stop-character in little more than 0.001 sec.

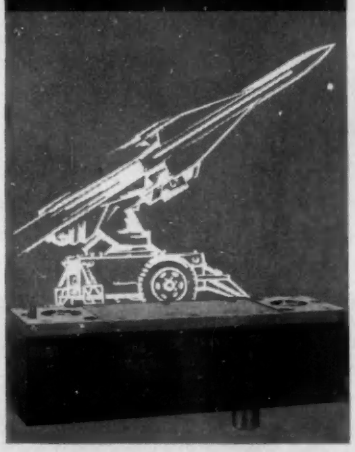
Any standard-width commercial tape, from five-level to eight-level code, can be fed into the unit from specially-designed plastic reels, which also provide inexpensive storage for the tapes. Two sizes of reels hold either 350 or 700 ft containing 40,000 or 80,000 characters. Automatic rewind and end-of-tape sensing minimizes operator intervention and automatic reel braking and servo shutoff prevents tape damage in the event of power failure, breakage, or other malfunction. The photoreader itself features rapid, simple, straightline loading.

Each component chassis of the unit mounts in standard 19-in. racks to allow the user maximum flexibility in system design.–Burroughs Corp., Pasadena, Calif.

Circle No. 203 on reply card

MODEL H-42

HIGH PRESSURE TRANSDUCER



In each Hawk missile launcher developed by Northrop Aircraft Inc., two Servonic H-42 pressure transducers provide damping in the servo systems which operate the azimuth and elevation controls. A radar impulse furnishes guidance and slews the missile carriage to the proper position for launch. The Servonic transducer senses the pending oscillation in the hydraulic system due to the inertia of the moving mass and applies a correction signal to the servo amplifiers controlling hydraulic pressure so that each oscillation is counteracted. This provides a stable motion as the platform is brought to rest in the correct firing attitude.

The use of the H-42 in the Hawk launcher servo systems is typical of the many application capabilities of Servonic pressure transducers in extreme environmental situations.

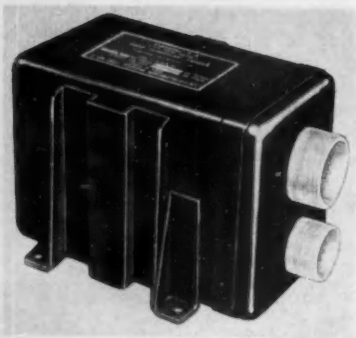
Range: ±4,000 psid.
Linearity: ±0.5%.
Hysteresis: Less than 1%.
Resolution: 0.2%.
Vibration Effects: Less than 1% at 20g.
Shock: 30g.

Complete Details in Technical Bulletin SI-581

SERVONIC INSTRUMENTS, INC.
640 Terminal Way
Costa Mesa, California

CIRCLE 99 ON READER-SERVICE CARD

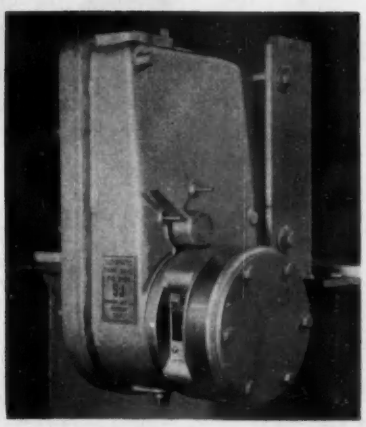
DATA HANDLING & DISPLAY



FOR PROGRAM CONTROL

Pictured is the MF-1 Missile Fire Intervalometer, designed to operate under extreme environmental conditions and still maintain precision timing accuracy. In service on supersonic aircraft, the MF-1 programs the opening of launcher doors, the lowering and firing of missiles in a preselected pattern, and the retraction of launchers and doors.—Abrams Instrument Corp., Lansing, Mich.

Circle No. 204 on reply card



EASY-TO-READ GAGE

This Model 2006 automatic tank gage features digital readout and a cast-aluminum housing. It has a clean design and readily accepts a transmitter for remote reading systems. Uniform tolerances on all machined parts and simple adjustment procedures assure high accuracy.—Shand & Jurs Co., Berkeley, Calif.

Circle No. 205 on reply card

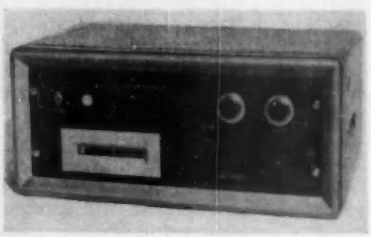
COMPACT RECORDER

Completely transistorized amplifiers and power supplies help reduce both size and weight of the new PS-200 Simplex multi-channel tape recorder. Two standard 10½-in. reels are located in a magazine attached to the tape transport. A loop magazine rapidly converts the recorder to tape-loop operation.

Characteristics:

Tape speeds: 1⅞ to 60 ips
Wow and flutter: under 0.1 percent at 30 ips
Number of channels: 1 to 14 on ¼-, ½-, or 1-in. tape
Power required: 175 watts for seven-channel recorder with 15 watts on standby
Dimenisons: 18 by 15 by 10 in. deep
Weight: under 50 lb
—Precision Instrument Co., San Carlos, Calif.

Circle No. 206 on reply card



DIGITAL INDICATOR

The Model 347 Digital Indicator consists of a servo-driven, self-balancing potentiometer with appropriate input and output circuitry. Output includes a five-digit illuminated readout, plus or minus indication, and an unambiguous electrical digital output for use with printer, punch card, or plotting machine.

Characteristics:

Input range: 0.5 to 4 mvdc
Accuracy: within 0.05 percent
Resolution: 1/14,000 counts
Response rate: 12,000 counts/min
—Dynametrics Corp., Burlington, Mass.

Circle No. 207 on reply card

REMOTE INDICATOR

A new device for remotely indicating machine tool position consists of a measuring unit or transmitter, cable-connected to a remotely-located indicator. The measuring unit, driven through a precision rack and pinion arrangement, contains two synchro transmitters, one for coarse and one for fine measurement. The indicator unit houses two similar receiving

...the record tells you more

from a SANBORN SYSTEM

DESIGNED SPECIFICALLY FOR YOUR TYPE OF WORK



MODEL 276 CHART VIEWER

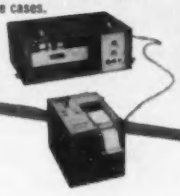
Permits convenient, variable speed editing and study of Sanborn charts and other types up to 16" wide, 200 ft. long. Single control for direction, paper speeds (15" to 100"/min). Transparent cursor slides left or right, adjusts for accurate alignment with coordinates.

1- TO 8-CHANNELS, 12 PLUG-IN PREAMPLIFIERS

150 SERIES



Features of the "150 series" direct writers include: frequency response to 100 cps; linearity 1% overall; inkless recording in true rectangular coordinates by heated stylus on plastic coated Permapaper charts; current feedback driver amplifier and regulated power supply for each channel. Recorder has 9 chart speeds, 0.25 to 100 mm/sec; individual stylus heat controls, time-code marker. Up to 6-channels can be housed in one vertical cabinet. Amplifiers, recorder also available in individual portable cases.



6-, 8-CHANNELS, FLUSH FRONT RECORDER, FREQUENCY RESPONSE TO 120 CPS

350 SERIES



New "350" series direct writers with compact plug-in preamps in modules of up to 4; individual power supplies; current feedback transistorized power amplifiers; limiter circuit ahead of power amplifiers; velocity feedback galvanometer damping; enclosed galvanometers. Linearity 0.2 div. over entire 50 divisions. Recorder-power amplifier-power supply package has 0.1 volt/div. sensitivity, can be used separately; pushbutton controls for 9 chart speeds 0.25 to 100 mm/sec; individual stylus heat controls; contacts for remote control; inkless rectangular coordinate recording on Permapaper charts.

6-, 8-CHANNELS

850 SERIES



Compact "850" series direct writers use 7" high plug-in preamplifiers in modules of up to eight and "350" flush front recorder package with transistorized power amplifiers, power supply; features velocity feedback galvanometer damping; linearity 0.2 div. over entire 50 divisions; 9 chart speeds from 0.25 to 100 mm/sec controlled by electric pushbuttons; inkless recordings on Permapaper charts. Available preamps include Servo Monitor (demodulator) and DC Coupling. Carrier, Chopper Stabilized and Low Level types are in development.

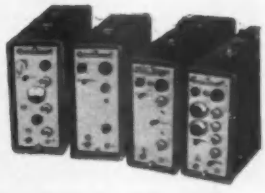
COMPUTER READOUT . . . AUTOMATIC PROGRAMMING

150 SERIES



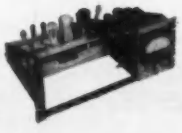
"150 series" 6-, 8-channel consoles in 46½" high mobile cabinet. Dual-Channel Amplifiers have selectable sensitivity from 0.01 to 10 volts/div.; internal calibration 2 volts ±1% freq. response flat to 20 cps. Optional Programmer sequences system operation in 20 steps, including recorder turn-on, calibration, computer DC level reading, recording for pre-set time, turn-off and reset.

SELF-CONTAINED UNIT PREAMPLIFIERS TO DRIVE 'SCOPES, OPTICAL OSCILLOGRAPHS, TAPE RECORDERS, ETC.



Portable "350" series include Carrier, DC Coupling Servo Monitor (demodulator), True Differential DC types; others in development. Mount in portable "450" cases or in four-unit modules in 19" frame. Use individual power supplies. One "450" case and power supply can serve any "350" Preamp.

PORTABLE INDICATORS FOR STRAIN, ETC.



Model 150-300/700 Wide Band Amplifier and Power Supply accepts "150" series preamplifiers — for use with low power galvanometers, oscilloscopes, panel meter. Freq. range DC to 10,000 cps (but limited by particular preamp range). Panel meter has center zero scale, 25 divisions each side of center.

(ALL DATA SUBJECT TO CHANGE WITHOUT NOTICE)

For complete data, call your local Sanborn Engineering Representative or write the Industrial Division in Waltham.

SANBORN COMPANY

Industrial Division

175 Wyman Street, Waltham 54, Mass.

"VISIT SANBORN BOOTHS 957-959 AT I.S.A. SHOW"

CIRCLE 100 ON READER-SERVICE CARD

New HIGH POWER 60 AND 400 CPS TRANSI-MAGS®

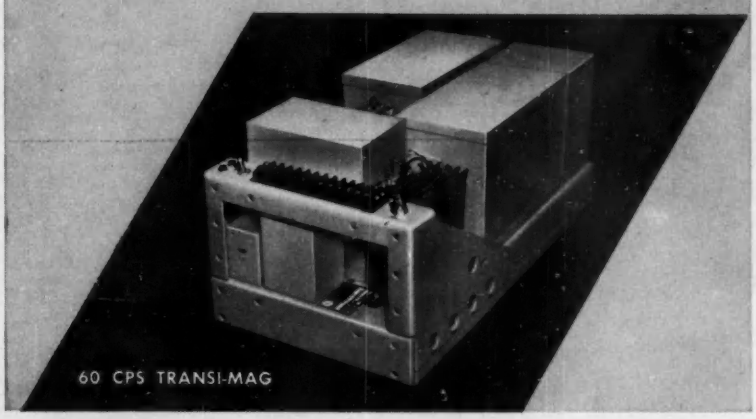
STANDARD LINE OF FAST RESPONSE

TRANSISTOR MAGNETIC AMPLIFIER

FOR SERVO MOTOR CONTROL

For driving AC servo motors in industrial and military servo systems which require hi-power, fast response and (static) high reliability.

A COMPLETE SERVO AMPLIFIER DRIVE SYSTEM IN A SINGLE PACKAGE
TEMPERATURE STABILIZED
FAST RESPONSE
HIGH GAIN
INSTANTANEOUS START
SMALL STANDBY POWER
RUGGED
HIGH RELIABILITY
QUADRATURE REJECTION
SERVO MOTOR COMPATIBILITY



60 CPS TRANSI-MAG

60 CPS PERFORMANCE SPECIFICATIONS

For complete 60 CPS and 400 CPS specs Write for Bulletins S-913 and S-914 Respectively

MODEL A.C. INPUT / D.C. INPUT	MA-1502 / MA-1511	MA-1559 / MA-1561	MA-1572 / MA-1581	MA-1602 / MA-1611	MA-1702 / MA-1711	MA-1802 / MA-1811	MA-1902 / MA-1911
MAX. POWER OUTPUT WATTS	50	100	120	175	650	1900	2800
TYPICAL SERVO MOTOR LOAD	DIEHL FPF 49-9	DIEHL FPF 49-12-1	DIEHL FPF 66-11-1	DIEHL FPF 85-18-1	DIEHL ZP 105-2212-1	DIEHL ZP 143-2247-1	DIEHL ZP 162-2207-1
SENSITIVITY	A.C. INPUT – 0.5V A.C. FOR FULL POWER OUTPUT D.C. INPUT – 2.5 MA D.C. FOR FULL POWER OUTPUT						
RESPONSE	0.1 seconds						
AMBIENT TEMPERATURE	– 55°C. to + 71°C.						

MA

MAGNETIC AMPLIFIERS INC.

632 TINTON AVENUE • NEW YORK 55, N. Y. • CYPRESS 2-6610

West Coast Division

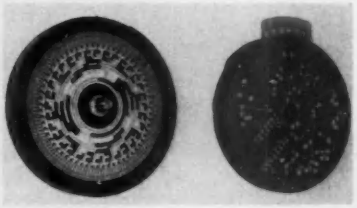
136 WASHINGTON ST. • EL SEGUNDO, CAL. • OREGON 8-2665

CIRCLE 101 ON READER-SERVICE CARD

NEW PRODUCTS

synchros, two optical dials, and a servomotor generator. The receiver synchros deliver a voltage proportional to the displacement difference between transmitter and receiver. This voltage is amplified and drives the servomotor until the voltage difference disappears. Tool position is then read from a ground glass dial. A synchro disconnect switch on the indicator permits rapid zero setting of the dial.—Contraves AG, Zurich, Switzerland.

Circle No. 208 on reply card



AMBIGUITY ELIMINATED

Well-suited for computer control applications, this miniaturized, 10-bit analog-to-digital shaft converter features high resolution with no ambiguity. A staggerd double-track design and transistorized logic circuits provide the 10-bit resolution on a 3½ in. disc. Ambiguity is eliminated by feed brushes and a system of logic incorporated in the disc pattern.—Librascope, Inc., Glendale, Calif.

Circle No. 209 on reply card

PLUS . . .

(210) A new line of pre-set electronic **counters,** featuring a maximum rate of 5,000 counts per sec, is now being offered by **Erie Resistor Corp.,** Erie, Pa. . . . (211) **Performance Measurements Co.,** Detroit, Mich., boasts a 0.15 percent maximum error for its new **digital-strain-gage indicator** for multiple-transducer installations. . . . (212) **Wang Laboratories, Inc.,** Cambridge, Mass., has announced a new series of **block readers** for standard 1-in., five-to-eight-hole paper or Mylar tape. . . . (213) A new **transistorized preset counter** developed by the **Dynapar Corp.,** Skokie, Ill., features long-life components and direct readout. . . . (214) **Midwestern Instruments,** Tulsa, Okla., has introduced the Model 707 **tape recorder** for direct analog, PDM and FM recording.

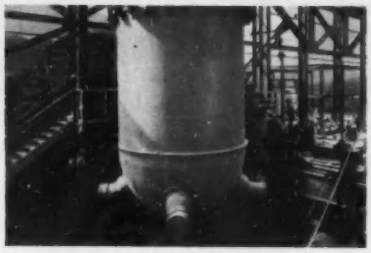
Circle No. 210, 211, 212, 213, or 214, on reply card

YOUR FUTURE IS GREAT IN A GROWING AMERICA



ELECTRONICS

Electronics is one of our fastest growing industries. By 1965 there will be thousands of new needs and new jobs.



NUCLEAR ENERGY

Nuclear energy is now supplying power for ships and electric plants. Future possibilities are virtually unlimited.



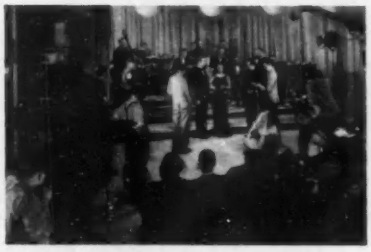
HEALTH

Ever-increasing opportunities in research, development and production. In the field of antibiotics 50% more workers will be required.



CHEMICALS

Today there are more than 800,000 workers in chemicals and related industries. By 1970, there will be *twice* as many!



COMMUNICATIONS

As our nation grows, the demands made upon communications grow proportionately. Thousands more needs, more jobs.



EDUCATION

The giant school-building program now beginning will offer new jobs to many thousands of construction workers.



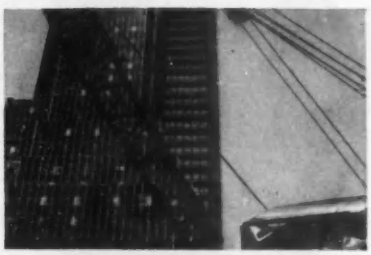
TRANSPORTATION

Our growing population demands constantly increasing mobility. Result: thousands of new opportunities, new jobs in the coming Jet Age.



FOODS

The trend is to labor-saving, ready-to-eat packaged foods. This new phase of an old industry will need thousands more workers.



CONSTRUCTION

3 million workers will benefit from new highway and construction programs—and even more workers will be needed soon.

7 BIG REASONS FOR CONFIDENCE IN AMERICA'S FUTURE

1. MORE PEOPLE—Four million babies yearly. U. S. population has *doubled* in last 50 years! And our prosperity curve has always followed our population curve.

2. MORE JOBS—Though employment in some areas has fallen off, there are *15 million* more jobs than in 1939—and there will be *22 million more* in 1975 than today.

3. MORE INCOME—Family income after taxes is at an all-time high of $5300—is expected to pass $7000 by 1975.

4. MORE PRODUCTION—U. S. production *doubles* every 20 years. We will require millions more people to make, sell and distribute our products.

5. MORE SAVINGS—Individual savings are at highest level ever—*$340 billion*—a record amount that is now available for spending.

6. MORE RESEARCH—*$10 billion* spent each year will pay off in more jobs, better living, whole new industries.

7. MORE NEEDS—In the next few years we will need more than *$500 billion* worth of schools, highways, homes, durable equipment. Meeting these needs will create new opportunities for everyone.

* * *

Add them up and you have the makings of another big upswing. Wise planners, builders and buyers will act now to get ready for it.



MARKETING

Marketing includes sales, consumer research, product and package design, advertising and public relations. All need new skills every year—and *many thousands* of new workers!

FREE! Send for this new illustrated booklet, "Your Great Future in a Growing America." Drop a postcard to: ADVERTISING COUNCIL, Box 10, Midtown Station, New York 18, N.Y.



HELIPOT'S newest potentiometer... the single-turn, 1-1/16" A.I.A. diameter, all-metal series 5200... fends off 2,000 cps at 30G's, repels 10 cycles NAS 710, procedure III humidity, rides out 50G's shock and 100G's acceleration.

We're tough, too... on the 5200's mechanical tolerances. Register face, diameter and shaft runouts are all held to 0.001" max... spring-loaded shaft eliminates endplay.

All this with linearity to ± 0.15%... power rating of 3 watts at 100°C (derating to zero at 150°)... 250 to 100,000 ohms standard resistance range... *and certified test data to prove our every claim.*

What a pot for airborne applications... at a down-to-earth price! *Write for data file G 92 for the proven facts.*

Beckman® / Helipot®

Helipot Division of Beckman Instruments, Inc.
Fullerton, California
Engineering representatives in 27 cities.

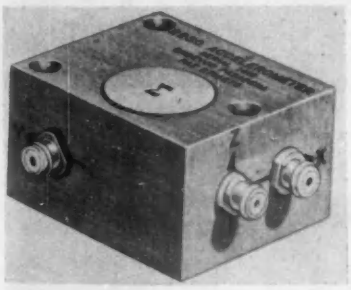
potentiometers... dials... delay lines...
expanded scale meters...
rotating components... breadboard parts



1431

CIRCLE 103 ON READER-SERVICE CARD

PRIMARY ELEMENTS & TRANSDUCER



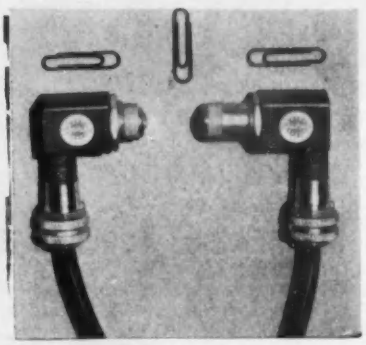
G-METERS

Two new tri-axial accelerometers meet the new vibration specifications for simultaneous measurements on three axes.

Characteristics:

Temperature range: −100 to +500 deg F for Model 2243 and 63 to 200 deg F for Model 2230
Natural frequency: 25 kc, both units
Sensitivities: 5 to 9 mv per g
Size: 0.75 in. x 1.25 in. x 1.31 in.
—Endevco Corp., Pasadena, Calif.

Circle No. 215 on reply card



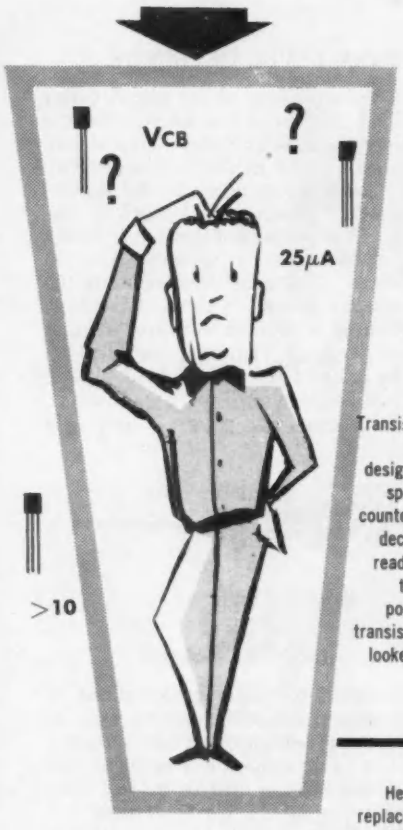
NEW PHOTOHEADS

These miniature photoheads, only slightly longer than a standard paper clip, are said to solve the problem of mounting a sensing device in a limited space. Their manufacturer claims an average light source life of 5,000 hours. They may also be used as reflected beam photoheads, and can be furnished with alignment brackets to assure proper relationship between light source and receiver.—Post Electronics, Beverly, Mass.

Circle No. 216 on reply card

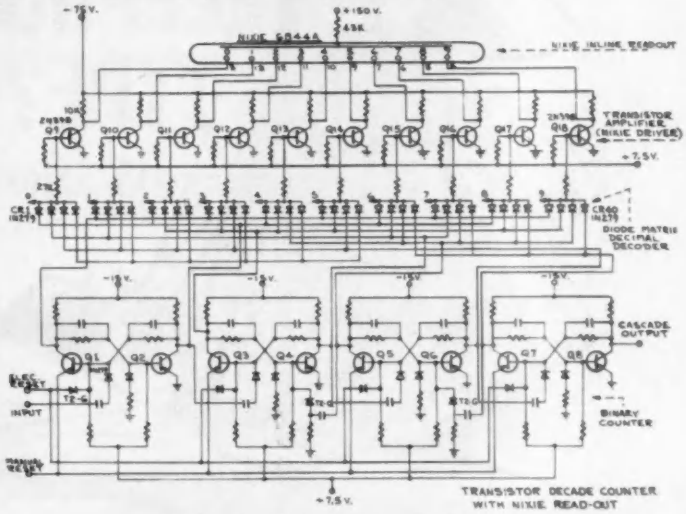
CIRCLE 104 ON READER-SERVICE CARD→

are you a victim of ENGINEERING HYSTERISTOR?*



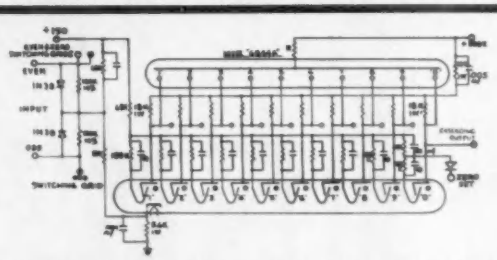
* EPIDEMIC SYMPTOMS:
HYSTERICAL
TOTAL USE OF TRANSISTORS

Transistor expert, Bill Binary, designed a high-speed decade counter requiring decimal in-line readout. He did the best job possible (with transistors) and it looked like this:



TRANSISTOR DECADE COUNTER WITH NIXIE READ-OUT

He could have replaced eighteen (18) transistors and forty (40) diodes with one (1) Beam Switching Tube like this:

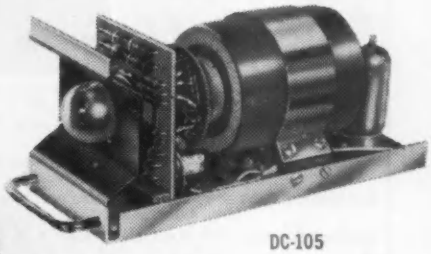


BEAM SWITCHING TUBE DECADE COUNTER WITH NIXIE READ-OUT

ANALYSIS: Transistors like ordinary tubes or cores are essentially binary devices.

REMEDY: Use a decimal component like Beam Switching Tubes to perform a decimal function.

LIVING PROOF:
Burroughs Decade Counter Type DC-105 With Nixie® In-Line Readout operates at 1 MC, has 10 outputs for remote readout or printout and reset time of less than 1 microsecond — **COST $145**



DC-105

YOU SHOULD KNOW ABOUT BEAM SWITCHING TUBES BECAUSE :

A single cathode controls an electron beam to any one of 10 constant current outputs each of which has individual bi-stable beam locking and high impedance switching.

You will find Beam Switching Tubes being used regularly to outperform other components wherever there is: distributing, switching, multiplexing, counting, sampling, coding, timing, gating, matrixing, memory, dividing, decoding, converting, or presetting.



FOR NEW CATALOGUES ON (1) BEAM SWITCHING TUBE, (2) DECADE COUNTERS, (3) NIXIE® ALL-ELECTRONIC IN-LINE INDICATOR TUBE, AND (4) PULSE CONTROL EQUIPMENT.

write

Burroughs Corporation

ELECTRONIC TUBE DIVISION

Plainfield, New Jersey



TRY
THIS
NUMBER
TQ-2C/24VD

(At right) Advance TQ type is our smallest telephone relay: Length, 1 11/32"; Width, 25/32"; Height, from 1 1/2" to 1 13/32".



SPECIFICATIONS

Coil resistance, 2C: From 40 Ohms at 6 volts, DC, to 12,000 Ohms at 110 volts, DC.

Coil resistance, 6C: From 10 Ohms at 6 volts, DC, to 5,000 Ohms at 110 volts, DC.

Nominal power required: 2C, 1.0 watts nominal (appr.); 6C, 3.0 watts nominal, (appr.).

Contact rating: 3 amps resistive, 1 amp inductive at 115 volts AC or 26.5 DC.

Contact arrangement: Available in form A, B, C, D, or E, up to a maximum of 6 Poles.

All Advance Telephone Relays feature small size, short armature travel, and highly efficient magnetic structure. In addition to the type TQ "Miniature" telephone relay (illustrated), which has a contact rating of 3 amps resistive, Advance also offers the TF "Midget" the TD "Small" and the TS "Sensitive." All with a contact rating of 5 amps.

Available From Leading Distributors

WRITE FOR COMPLETE DETAILS

You'll want all 4 data sheets for your file: TQ, TF, TD & TS.



ADVANCE RELAYS

ELGIN A PRODUCT OF ELECTRONICS DIVISION
ELGIN NATIONAL WATCH COMPANY
Dept. F, 2435 N. Naomi St., Burbank, California

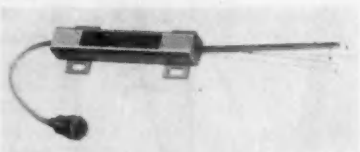
CIRCLE 105 ON READER-SERVICE CARD

NEW PRODUCTS

TANK LEVEL DETECTOR

Chief advantage of the new AccuRay level detector is that no part extends into the tank or vessel. Thus it cannot be fouled by the process material, and it is readily accessible for maintenance. One unit provides high- or low-level, or high- and low-level signals. In operation, a suitable radiation source is installed either opposite the detector or across a chord of the tank. Control is accurate to within $\frac{1}{16}$ in. at set level. A Thyratron-controlled relay provides the output signal.—Industrial Nucleonics Corp., Columbus, O.

Circle No. 217 on reply card



SELF-ALIGNING SHAFT

Designed to eliminate the effects of bending loads and vibratory motion, Model 156 Align-O-Pot uses a floating shaft to sense linear displacement. Vibration error is said to be less than resolution at 15 g's for travels less than 2½ in. and at 25 g's for travels from 2½ to 4 in. Available travels range from ½ to 6½ in. The model is offered with single or dual outputs in resistance values of 1, 2, 5, 10, 20, and 50 k.—Bourns Laboratories, Inc., Riverside, Calif.

Circle No. 218 on reply card

NO COOLING NEEDED

AXT-series self-generating accelerometers operate at temperatures of from minus 100 to plus 500 deg F, and are accurate to within 5 percent of the actual reading. Bender-type piezoelectric construction reduces size and weight, and permits high-frequency response. Applications include shock and vibration measurement in missiles and aircraft.—Gulton Industries, Inc., Metuchen, N. J.

Circle No. 219 on reply card

PLUS . . .

(220) A new linear accelerometer featuring frictionless operation has been introduced by Minneapolis-Honeywell Regulator Co., Boston, Mass. . . .

New

FROM ITT *Components Division*

"TANTALIT" capacitors

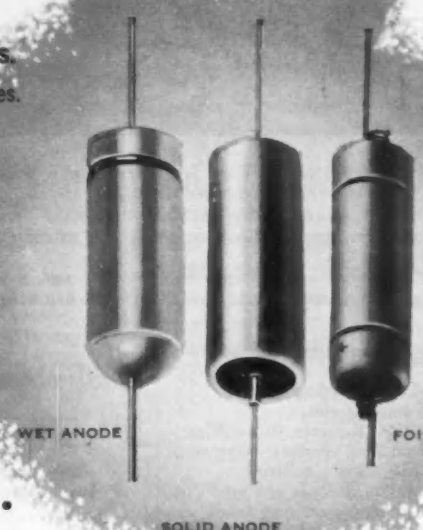
Complete line of miniature tantalum capacitors for industrial and military applications.

Only I T T offers you these outstanding advantages.

- **Superior Product — Competitively Priced**
  Backed by world-wide engineering, research and manufacturing experience.
- **Widest Ranges of Product Type**
  Wet Anode, Solid Anode, Foil Type Tantalum and Miniature Aluminum Dry Electrolytic Capacitors.
- **Long Shelf Life — High Operating Reliability**
  Protect your investment and reputation.
- **Availability**
  Network of warehouse and stocking distributors assure dependable delivery.
- **Design Features**
  Hermetically Sealed • Small, lightweight • withstands high shock and vibration • electrical stability • complete uniformity •
- **Temperature Ranges**

wet anode:	−55° C to +125°C
solid anode:	−80° C to + 85°C
foil type:	−40° C to + 85°C
miniature aluminum:	−40° C to + 85°C

Write today for complete technical information.



ITT *Components Division*

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

P. O. BOX 412 CLIFTON, NEW JERSEY

CIRCLE 106 ON READER-SERVICE CARD

another Potter First



THE
NEW POTTER "909"

Now... a device that READS and STOPS faster, better

The compact '909' Perforated Tape Strip Reader now makes it possible to process information from perforated tape into digital data computer systems at high speed and low cost. Simple to operate by clerical personnel, the '909' is completely transistorized, and will give maximum performance with complete reliability.

The '909' is a compact unit, suitable for console or rack mounting. Here are some of the performance features, available for the first time in equipment of this type:

- Character reading speeds up to 1000 char/sec.
- Simple In-Line threading
- 3 Millisec starting time
- Stops on STOP Character, (0.2 millisec) and will read next character after start
- 100 x 10^6 operation pinch roll
- Photo Diode Head reads any tape (including oiled yellow teletype tape)
- Reads 5, 6, 7 or 8 level tape with sprocket channel
- Ambient temperature up to 125° F. with 10,000 hour life
- Built to meet requirements of MIL-E-4158A

Specifications

Tape Speed:
10 to 100 ips
Tape Width:
Any Standard Width
Power Requirements:
115V, 60 Cycle, 1 Phase
Control:
Remote/Level Inputs

Contact your Potter representative or call or write direct for further information.

Potter
The mark of Engineering Quality

POTTER INSTRUMENT COMPANY, INC.
Sunnyside Boulevard, Plainview, N. Y.
OVerbrook 1-3200

Potter has career opportunities for qualified engineers who like a challenge, and the freedom to meet it.

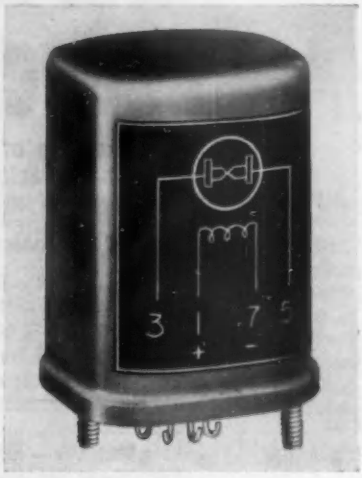
CIRCLE 107 ON READER-SERVICE CARD

NEW PRODUCTS

(221) **Fischer & Porter Co.**, Hatboro, Pa., recently expanded its line of force-balance **differential pressure transmitters** in which measuring circuits are completely immersed and sealed in silicone oil. . . . (222) A novel **bunker-level indicator** by **Siemens & Halske,** Erlangen, Germany, uses a pear-shaped metal plummet to scan levels of materials stockpiled in bunkers from 12 to 38 ft high.

Circle No. 220, 221, or 222, on reply card

CONTROLLERS, SWITCHES & RELAYS



NO MOVING PARTS

The coil circuit in this new electronic relay operates on 28 vdc, pulls in at 18 volts, and drops out at 7 volts or less, with a positive snap-action operation. Completely isolated from the electronic switching circuit, the single coil circuit can handle a number of independent circuits within one unit. The unit will switch either ac or dc and has a transfer time of less than 50 μsec. Other features include no arcing, no contact bounce, and long life.–Pendar, Inc., Los Angeles, Calif.

Circle No. 223 on reply card

WIDE SPEED RANGE

The new MG Series of timers and multi-speed drives features speed ratios as high as 2,419,200 to 1. Units





Victor Regulators control high pressure gases...safely and accurately

GD700 SERIES for testing pneumatic components or operating gas systems. Gas-O-Dome primary regulator is controlled by a relief venting, high pressure, spring loaded regulator. This combination offers you precise regulation for both low or high volume applications.

MODEL	PSI MAX. INLET	PSI OUTLET RANGE	GAUGES (integral or panel mounting)
GD710	7000	400-7000	10,000-10,000
GD711	7000	200-3600	10,000- 5,000
GD712	7000	200-2000	10,000- 4,000
GD713	7000	50- 800	10,000- 1,000
GD714	7000	10- 150	10,000- 200
GD700	3600	200-3600	5,000- 5,000
GD701	3600	200-2000	5,000- 4,000
GD702	3600	50- 800	5,000- 1,000
GD703	3600	10- 150	5,000- 200

Flow: Approx. 300 scfm. Leakage: None.
Operating temp. range: −67° F to +200° F (Storage −80° F)

LR SERIES Loading Regulators for "dead end" and low capacity testing (2 sfcm.) of pneumatic components, or for operating gas systems. Will hold dead-end pressures without leakage—also will hold supply pressure even when inlet pressure decreases.

MODEL	PSI MAX. INLET	PSI OUTLET RANGE
LR20B	7000	40-7000
LR19B	7000	20-3600
LR18B	7000	15-2000
LR17B	7000	10- 800
LR16B	7000	5- 200

Operating Temp. Range: −67° F to +200° F (Storage −80° F)
Leakage: None.

BOTH GD700 AND LR SERIES are field proved. They regulate all non-corrosive gases, including oxygen. Forged bronze bodies; stainless steel trim; Kel-F seats; internal filters; built-in adjustable relief. Proof pressure 2 times rated pressure; burst pressure 3 times rated pressure. Panel mounting. Stainless steel models available for corrosive gases. For complete specifications, write us today.

VICTOR for welding

VICTOR EQUIPMENT COMPANY

Mfrs. of welding & cutting equipment; high pressure and large volume gas regulators; hardfacing rods, blasting nozzles; cobalt & tungsten castings; straightline and shape cutting machines.

47

844 Folsom St., San Francisco 7 • 3821 Santa Fe Avenue, Los Angeles 58 • 1145 E. 76th St., Chicago 19
J. C. Menzies & Co., Wholly-Owned Subsidiary

CIRCLE 108 ON READER-SERVICE CARD

MEASURING UNIT

A. A thermocouple signal to a d'Arsonval galvanometer, the only moving part, moves the indicating pointer up scale.

B. Aluminum vane adjusts the amount of light received by the photocell from the operating lamp.

C. If operating lamp or photocell fails, output voltage assumes a value equal to high temperature.

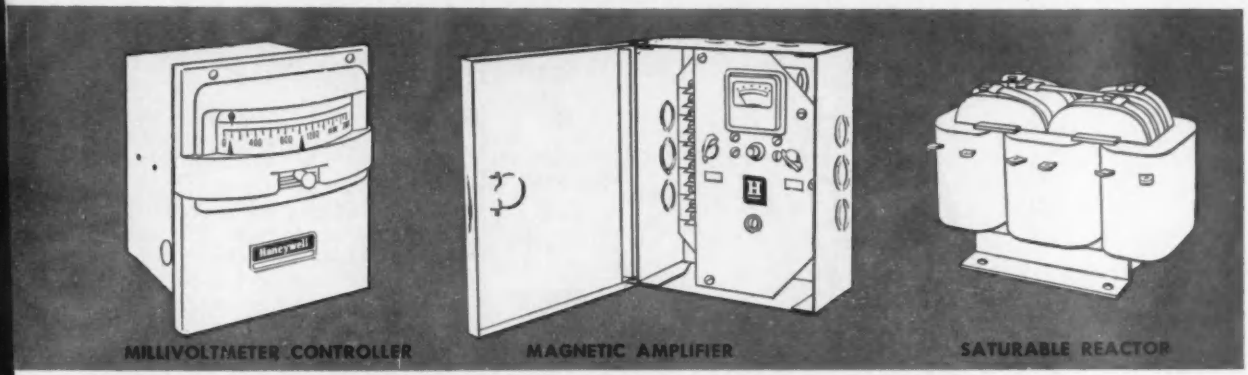


CONTROL UNIT

D. A one-stage magnetic amplifier amplifies small current from the photocell in the measuring unit. This is the only active electronic element in the controller.

E. Pilot light goes out on line power failure.

Pyr-O-Volt **controller is dependable and trouble-free. Built-in voltage regulator maintains voltage within ±1% of level required for maximum operating stability. Thermocouple burnout protection is optional. Spare operating lamp is supplied with all instruments. Available in both horizontal and vertical case models.**



For your electric heating applications...

Use this dependable, low-cost *Pyr-O-Volt** controller

- **No tubes to wear out**
- **Voltage regulation**
- **Fail-safe design**
- **Contactless, stepless control**

Here's a low-cost instrument for reliable stepless control of saturable reactors, r.f. generators and other power amplifiers. It has a proportional band adjustable from ⅔% to 5%, and a manual reset adjustment which shifts the control point over 100% of the proportional band.

You can use this proportional output millivoltmeter-controller with the General Electric *Reactrol***, and the Westinghouse *Furnatron*.*** Combined with a Brown magnetic amplifier, it can control saturable core reactors up to 100 kva. Complete packaged systems available.

Contact your nearby Honeywell field engineer for complete details. He's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

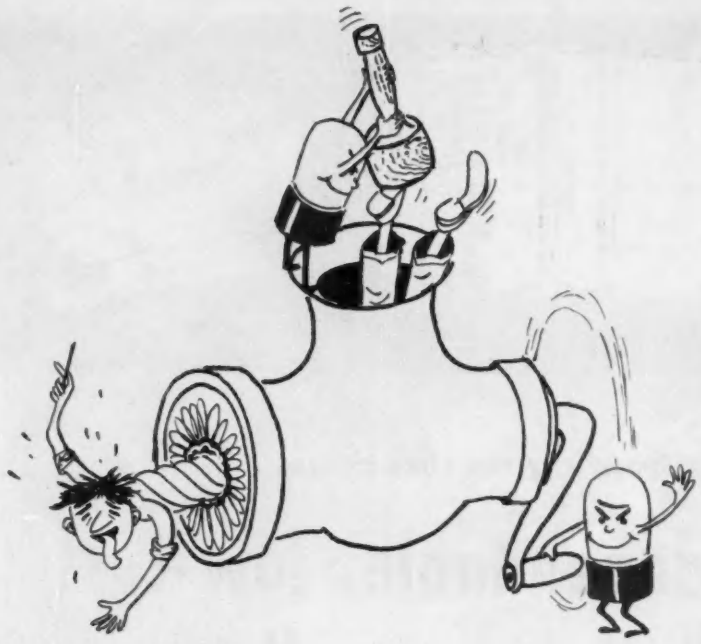
Honeywell

H HONEYWELL *First in Control*

● **REFERENCE DATA: Specification S103-5**

*Tradename, Minneapolis-Honeywell Regulator Co.
**Tradename, General Electric Co.
***Tradename, Westinghouse Electric Corp.

CIRCLE 109 ON READER-SERVICE CARD

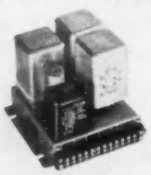


You got problems in electronics?

For those of you who appreciate the miraculous things only Electronic Devices can do, but who've suffered defeat once too often at the hands of a perverse circuit of your own design, Sigma once again rises grandly to the occasion. A special group is now working full time designing devices which do not require a Ph. D. to turn them on or a computer to give them orders. Our new endeavor will be called the Foolproof Equipment Division, and it will be headed by J. Bellingham Dipole, a recognized authority on such things as self-quenching martinis and superregenerative smudge pots. Dipole may be a little weak on theory, but he can whip together a box of assorted gimcracks and one Sigma relay and make it work every time.

Already the F. E. Division has a dandy product that certainly will solve somebody's electronics problem—maybe even yours. By hitching it up to a thermistor bridge, resistance thermometer, photocell, ionization gauge, load cell or similar pickup, you can control or monitor such things as temperature, light level, vacuum, radiation level, pressure and so on. What it does is compare currents, voltages or resistances—on low impedance DC input signals of less than 0.1 microwatt. Since this device is more rugged than a tube amplifier or meter relay, and isn't harmed the way a transistor amplifier would be by a continuous input power overload of 10 million, it must be a magnetic amplifier. It is—all in one neat package that *includes* the relay (s) you would need anyway. You can run this Magnetic Amplifier Relay on 7-day-a-week jobs, and it's also probably the least expensive way you'll find to do them.

That's a standard model in the picture; other types and numerous special features (e. g., desensitizing control, multiple wound coils, ultra-sensitive relay for 0.02 microwatt inputs) are all catalogued in a new bulletin just printed. If you got problems, maybe you should write for one.



SIGMA INSTRUMENTS, INC.

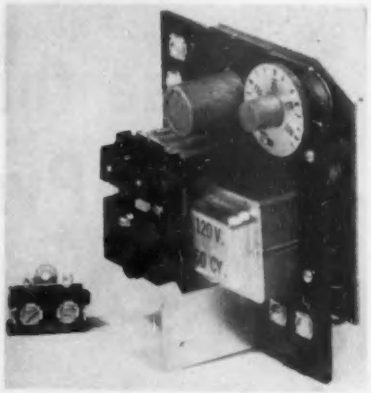
69 Pearl Street, So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1930)

CIRCLE 110 ON READER-SERVICE CARD

are available with either 10 or 13 exact output speeds, one or four output shafts, and reversing or non-reversing motors. Accessories include switches, adapter plates, and either solid or adjustable cams. Prices without accessories range from $37.50 to $175. Applications include both single and multiple switching, programming, sampling, and driving a variety of control equipment.—Gorrell & Gorrell, Westwood, N. J.

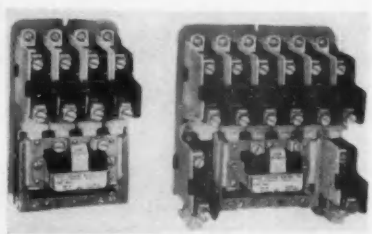
Circle No. 224 on reply card



VERSATILE CONTROLLER

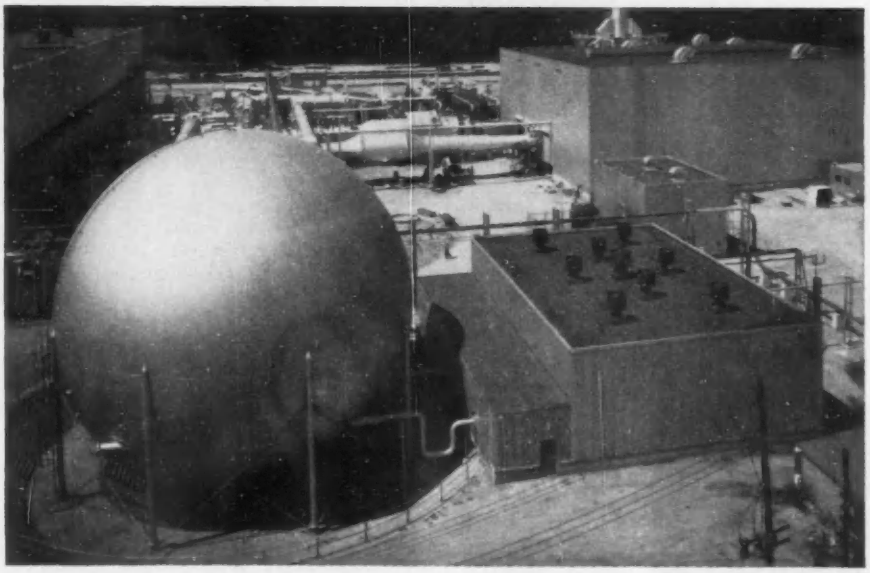
Photo above shows a new transistorized amplifier relay system designed to sell for just under $60. Well-suited for industrial applications, the system consists of a compact amplifier, which controls temperature, and a vibration-proof mounting containing a thermistor sensing element. Relays are available in eight overlapping ranges of approximately 100 deg F each to permit control from minus 60 to plus 520 deg F. They have a resistive load rating of 1,500 watts at 240 volts.—Control Device Div. of Minneapolis-Honeywell, Minneapolis, Minn.

Circle No. 225 on reply card



10-AMP RATING

Specifically designed for industrial



THE E-2 BLOWDOWN TUNNEL at the Arnold Engineering Development Center, Tullahoma, Tennessee. At this wind tunnel center of the Air Research and Development Command, air at pressures up to 4000 psi, stored in a 720' long cylinder, flows into the evacuated sphere through the tunnel which is housed in the building to the right. Construction of the facility is under supervision of the U.S. Army Engineer District, Tullahoma. Three Hagan PowrAmp Model A-2 pressure transducers and two Model 80 electro-hydraulic pilot valves, in conjunction with a Hagan control computer, control stilling chamber pressure.

blowdown wind tunnels with HAGAN CONTROLS

...heavy duty power...laboratory accuracy

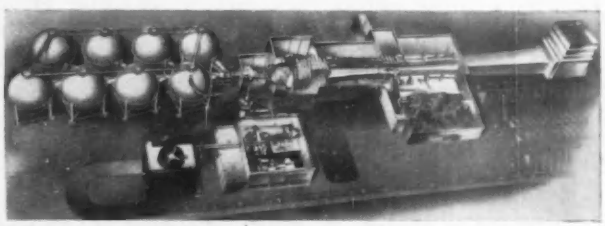
Hagan's PowrAmp control components have proved their ability to perform under exacting operating conditions, such as encountered in supersonic wind tunnel installations. Rugged enough to withstand the punishment of heavy usage and fast enough to keep pace with the high speed changes which occur in blowdown tunnels, Hagan control systems have exceeded the accuracy requirements of these tunnels.

The PowrAmp line includes transducers for most key variables, electronic control computers and pneumatic, hydraulic and electro-hydraulic operators and pilot valves. These high-speed, accurate electro-hydraulic and electronic automatic control devices are available separately, or assembled as pre-planned control systems. Applications include the control of temperature, pressure, flow, density, level and position.

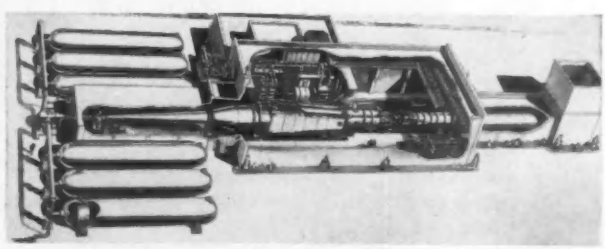
The Hagan PowrAmp line is supplemented by Hagan Kybernetes Division, providing the most advanced techniques in data logging and monitoring applications.

Write for PowrAmp Bulletin M.S.P.-133, or the Kybernetes Bulletins.

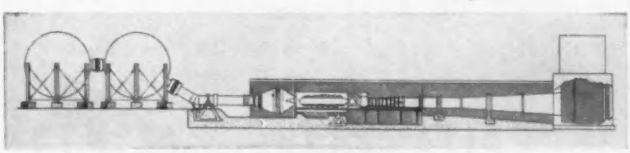




NORTH AMERICAN'S TRI-SONIC blowdown wind tunnel at El Segundo, built by Pittsburgh-Des Moines Steel Company, is the largest tunnel of this type in existence. Hagan PowrAmp stilling chamber pressure control has met the performance specifications, controlling velocities up to Mach 3.5.



THE CONVAIR TUNNEL, built by Chicago Bridge and Iron Company, is located at San Diego. Used for both missile and aircraft tests, its operating range is from Mach 0.5 to Mach 5.0. Hagan conducted a complete analog study in designing the control system. Actual operation has exceeded predicted performance.



BOEING AIRPLANE COMPANY'S blowdown tunnel, built by Pittsburgh-Des Moines Steel Company, is also equipped with Hagan PowrAmp controls. Airspeeds as high as Mach 4.2 are produced in the Boeing Tunnel's 4' x 4' test section. A flow-forming nozzle, variable from one to sixteen square feet, controls speed and smoothness of the air. Hagan stilling chamber control equipment includes Model A-2 pressure transducer and electro-hydraulic pilot valve.

HAGAN CHEMICALS & CONTROLS, INC.

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

NEW



MINIATURE AGASTAT®

time delay relay

for . . . missile, aircraft and electronic applications

INSTANTANEOUS RECYCLING . . . reset time—less than .020 seconds

UNAFFECTED BY VOLTAGE VARIATIONS . . . time delay remains constant from 18 to 30 volts DC

ADJUSTABLE . . . time delays from .030 to 120 seconds

CHOICE OF OPERATION . . . for either energizing or de-energizing

SMALL . . . height—4⅝" . . . width—1-13/16" . . . depth—1½"

LIGHT . . . maximum weight—15 ounces

MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A

This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit, built to withstand the rugged environmental conditions of missile and aircraft applications.

For specific information on the new AGASTAT relay for your application, write to Dept. A29-9.

AGA DIVISION **ELASTIC STOP NUT CORPORATION OF AMERICA**

1027 Newark Avenue, Elizabeth, New Jersey

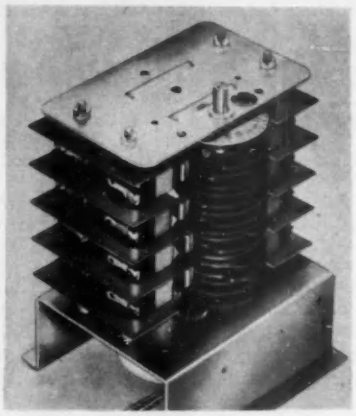
Pioneers in pneumatic timing

CIRCLE 112 ON READER-SERVICE CARD

NEW PRODUCTS

and machine-tool applications, a new line of multi-pole relays features unitized poles that can be replaced or reversed by loosening just one screw. These Type HR relays are available in ac and dc forms; they have a maximum of eight poles that can be arranged in any combination of n-o or n-c contacts. Contacts are rated at 10 amps, 600 vac. A cam-actuated wiping action assures long life for the double break silver-to-silver contacts. Pressure connectors are used on all terminals. – Ward Leonard Electric Co., Mount Vernon, N. Y.

Circle No. 226 on reply card



FIELD-ADJUSTABLE

Pictured is one of two new cycle timers that combine high accuracy with simple adjustability. Units will handle either one to three or four to eight independent timed intervals. Both throws of each spdt load switch are controlled by separate cams, independently adjustable through 180 deg. A graduated dial indicates cam setting in percent of full cycle time, permitting accurate setting of "make" and "break" times for each switch. Switching accuracy is within 1½ deg for any one circuit, 3 deg between any two circuits. Load switches are rated for 20 amp at 125 or 250 vac. –Cramer Controls Corp., Centerbrook, Conn.

Circle No. 227 on reply card

PLUS . . .

(228) **Micro Switch Div. of Minneapolis-Honeywell Regulator Co.**, Freeport, Ill., is offering a sub-miniature **spdt snap-action switch** that weighs just 1/28 oz. . . . (229) The new PE-3



Genesis of a GENESYS System

This Dynamic Memory Processor is a nucleus product creation of the Genesys Corporation. No product has ever approached all of its performance capabilities. A unique building block of advanced Genesys Systems, it achieves *seven giant steps forward* in economic, reliable process control using a minimum of associated hardware:

. . . stores a vast amount of control capability on a simple, reliable memory surface

. . . monitors, stores, logs information of any process or fabrication system

. . . makes correlative decisions

. . . performs extensive computation in the memory

. . . decides on "system optimization" control through learning logic

. . . assumes direct control of actuators and power elements

. . . checks itself automatically for optimum reliability



GENESYS CORPORATION

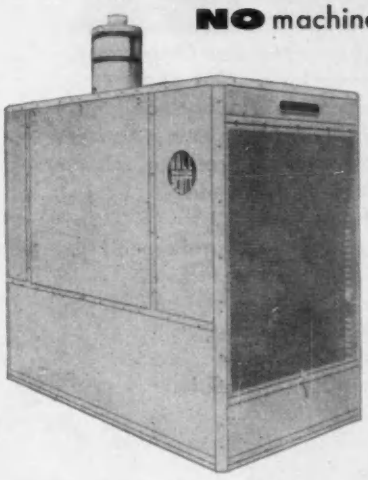
10131 National Boulevard • Los Angeles 34 • California

ADVANCED CONTROL COMPUTER SYSTEMS *for the petroleum, chemical and petrochemical industries*

See us in Booth 913 at the I S A *Show*

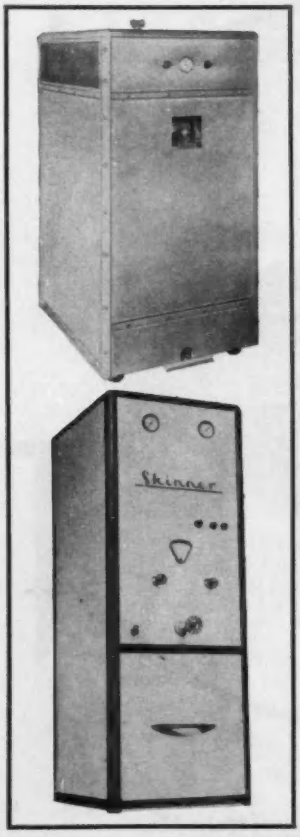
CIRCLE 113 ON READER-SERVICE CARD

NO special experience necessary!
NO new tools needed!
NO expensive dies required!
NO machines even for large units!



when you use
LINDSAY STRUCTURE
components for housings and enclosures . . .

and there is **NO DELAY** in changing models, sizes or other details that normally slow down production.



Readily adaptable, die-drawn Lindsay Structure components make it easy to prefabricate enclosures for instruments, testing machines, radio and radar equipment . . . and housings for processing, large towers, industrial equipment, and shielding (electromagnetic shielding through the entire radio frequency spectrum).*

All shapes and sizes are possible to any desired dimension within ½", using the 80,000 panel sizes immediately available. Lindsay Structure has given positive proof of its efficiency in hundreds of different applications . . . in many industries . . . and in all workable metals.

Whether you are planning 1 or 1,000 units . . . with Lindsay Structure you save the cost of expensive dies and "tooling" up.

You can begin production immediately . . . your assembly can be handled by workers without special training . . . and you are assured of complete uniformity in your finished units, when you use die-drawn, die-cut Lindsay components of exact size requirements.

Make use of Lindsay Structure components for your housing, enclosure, building or equipment requirements. Write for information, descriptive folder, or send single-line drawing for cost estimate.

*Lindsay Structure shielded enclosures supplied by Ace Engineering and Machine Company, Huntingdon Valley, Pennsylvania.

LINDSAY STRUCTURE DIVISION
INTERNATIONAL STEEL COMPANY
1425 Edgar Street • Evansville 7, Indiana
Canadian Affiliate:
Lindsay-International, Ltd., Port Credit, Ontario

CIRCLE 114 ON READER-SERVICE CARD

NEW PRODUCTS

Electronic Relay, made by **Farmer Electric Products Co., Inc.,** Newton Lower Falls, Mass., was designed for use with resistive type photoelectric scanning heads. . . . (230) The **Henry G. Dietz Co.,** Long Island City, N. Y., has announced a new class of **low pressure switches** designed to withstand high proof pressures without permanent damage or distortion. . . . (231) **Wallace O. Leonard, Inc.,** Pasadena, Calif., recently introduced a new high-pressure, high-flow **servo pneumatic regulator** for fuel and LOX pressurization applications.

Circle No. 228, 229, 230, or 231 on reply card

POWER SUPPLIES



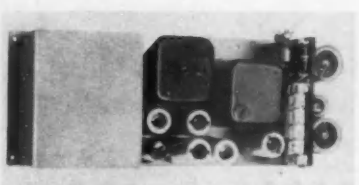
NEW TUBELESS SUPPLY

The Model SC-150-1 transistorized, voltage-regulated power supply shown here delivers 0 to 1 amp at 0 to 150 volts. Features include external overload and short-circuit protection, remote-error-signal sensing, and front and rear terminations.

Characteristics:

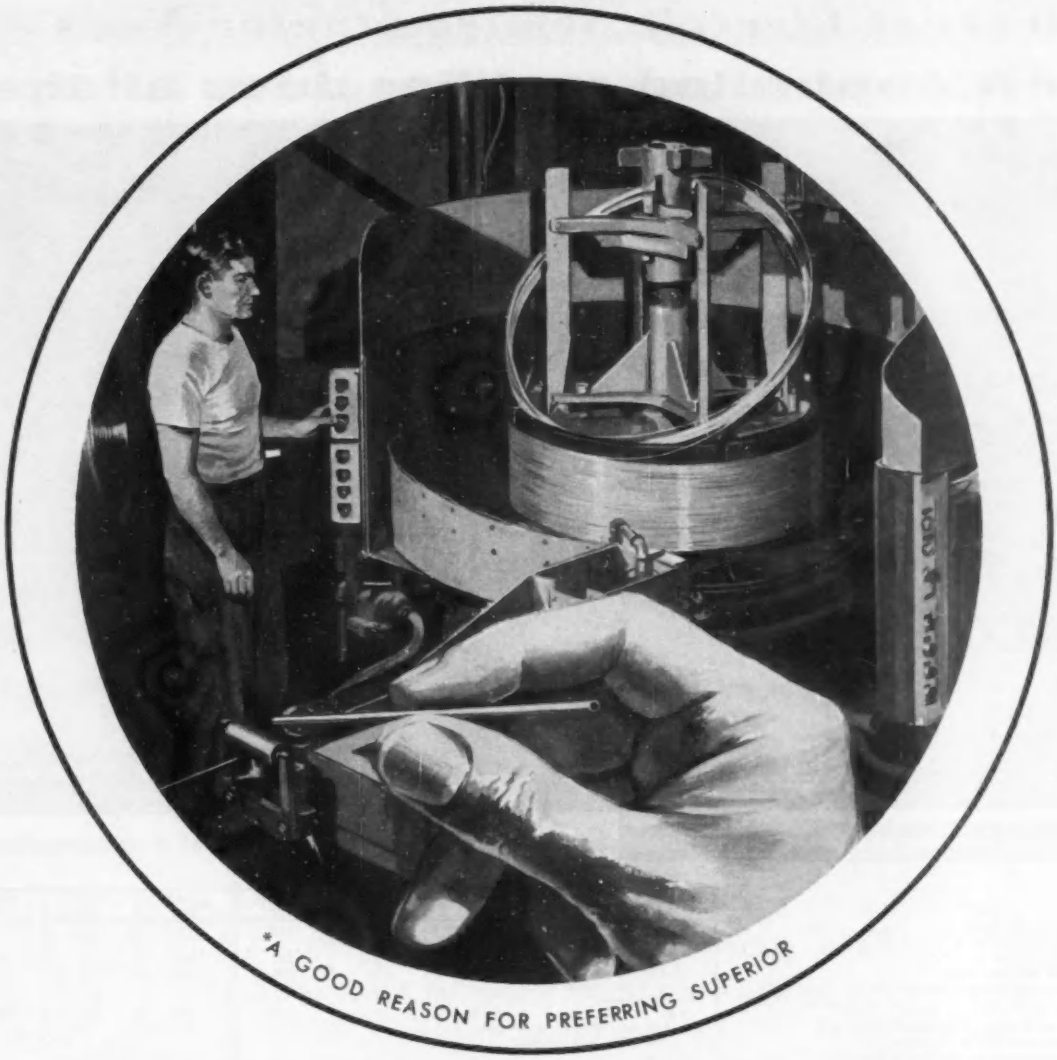
Regulation: 0.01 percent or 0.002 volt
Ripple: less than 1 mv, rms
Recovery time: less than 50 μsec
Operating temperature: 50 deg C max
—Kepco Laboratories, Inc., Flushing, N. Y.

Circle No. 232 on reply card



UNUSUAL INPUT SPECS

Input specifications of this new power supply are 115 volts, plus or minus 10 percent, and 60 to 400 cps. Any



New—capillary tubing in 3000 ft. lengths for industrial instrumentation

Improved bore uniformity, broader size range, flow tested to your specifications

To meet the demands of modern instrument design and automated fabrication, Superior is now offering seamless capillary tubing in lengths up to 3000 ft. It is available in nine different materials from select-quality raw stock, including stainless steel, carbon steel, nickel and nickel alloy.

Scrupulous care in manufacture results in a finished product that is bright and scalefree, with an extremely smooth, uniform bore. The tubing is easy to weld, braze or solder. ODs range up to 3/16 in.—IDs from .004 to .040 in. maximum.

When you order capillary tubing by Superior you are assured that your specifications will be met. In addition to 100% dimensional, pressure and finish inspections, we also can test lengths for flow rates with the latest equipment when specified. Rates can be varied from 5 to 3700 cc per min.

More information on Superior's improved capillary tubing products is yours for the asking. Send coupon today.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅛ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. RAymond 3-1331

SUPERIOR TUBE COMPANY
2026 Germantown Ave., Norristown, Pa.
Send me a copy of new Data Memorandum 11, on capillary tubing.

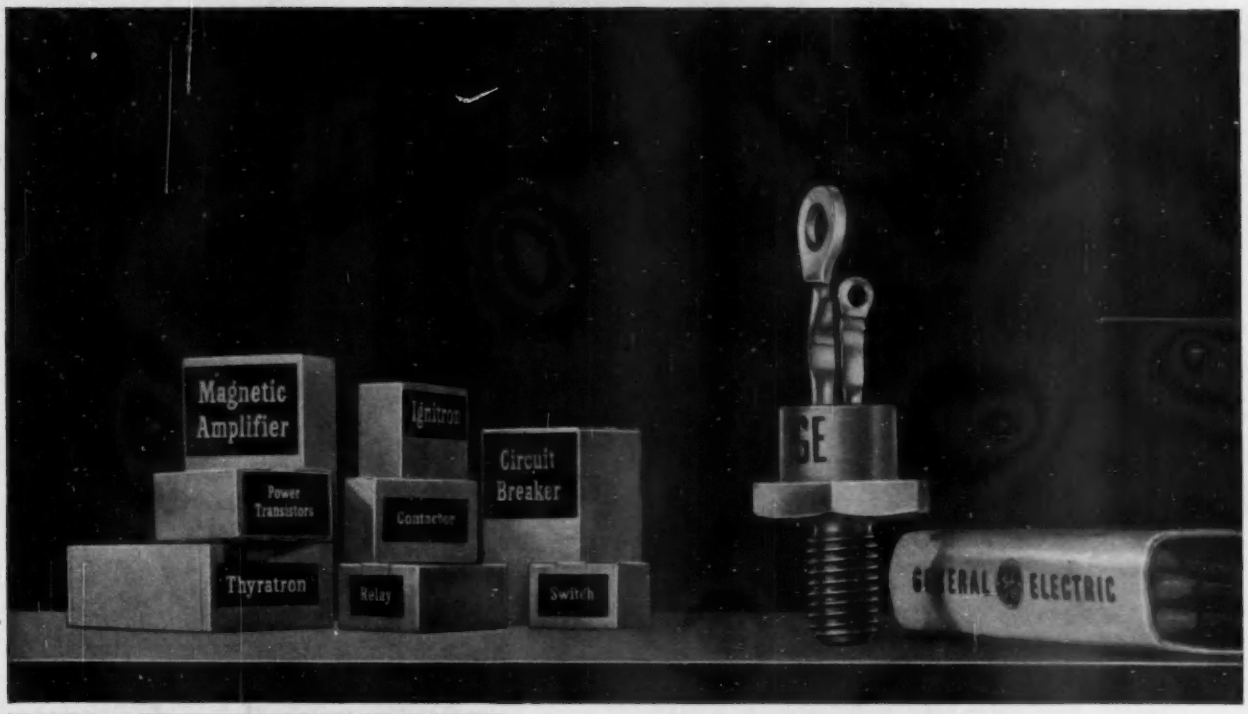
Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

New controlled rectifier does all these



Maximum Allowable Ratings and Characteristics

(Resistive or Inductive Load)

	ZJ39A 25	ZJ39A 40	ZJ39A 75	ZJ39A 100	ZJ39A 150	ZJ39A 200	ZJ39A 250	ZJ39A 300
Continuous Peak Inverse Voltage (PIV)	25	40	75	100	150	200	250	300 V
Transient Peak Inverse Voltage (Non-recurrent > 5 millisec)	35	60	100	150	225	300	350	400 V
RMS Voltage (Vrms)	17.5	28	53	70	105	140	175	210 V
Average Forward Current (I_F)	Up to 16 amperes							
Peak One-cycle Surge Current (i surge)	150 amperes							
Minimum Forward Breakover Voltage (V_{BO})	25	40	75	100	150	200	250	300 V
Maximum Forward Voltage (V_F Ave.)	0.75 Volts (Full Cycle Average)							
Maximum Reverse Current (I_R)	5 ma (Full Cycle Average)							
Maximum Gate Current To Fire (I_{GF})	25 ma							
Maximum Gate Voltage To Fire (V_{GF})	3 Volts							

Finer performance of G-E low-current silicon rectifiers now within reach for all your requirements

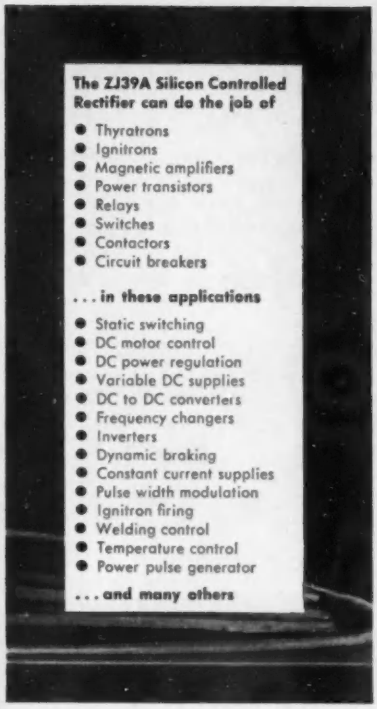
MAXIMUM RATINGS AND SPECIFICATIONS

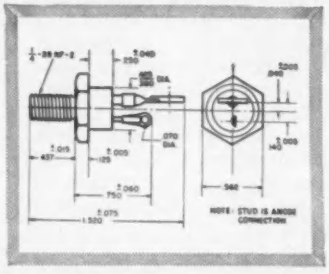
	PIV	RMS Voltage	Cont. Reverse D-C Volt	D-C Output (150°C Amb.)	D-C Output (50°C Amb.)	One-cycle Surge Current	Full-Load Forward Voltage Drop	Leakage Current	Ambient Operating Temp.
1N536-40, 1N1095-96 series	50-600	35-420	50-600	250	750	15	0.5	0.4-0.3	165
1N440B-445B series	100-600	70-420	100-600	300-500 (100°C)	300-750	15	0.5		150-165
1N1487-92 series	100-600	70-420	100-600	250 (125°C)	750 (25°C)	15	0.55	0.3	140
1N1692-95 series	100-400	70-280	100-400	250 (100°C)	600 (50°C)	20	0.6	0.5	115
	volts	volts	volts	ma	ma	amps	volts	ma	°C

The time has come to reconsider possible applications of G.E.'s outstanding low-current silicon rectifiers in the 1N536, 1N440 Series (150°C line) . . . the 1N1487 Series (125°C line) . . . and four recently added types in the 100°C area, the new 1N1692 Series. You'll find these devices more attractive to use than ever before—both in quality and price—with equally fine values in low-current silicon stacks. Stud-mounted units are also available.

General Electric low-current silicon rectifiers are designed for maximum forward conductance at high operating temperatures. High current loads are carried *without* external heat sinks. Reverse current at maxi-

jobs, and more—prices reduced 50%





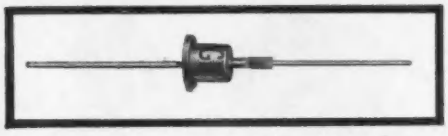
Price reductions in some cases greater than 50% will enable hundreds of new users to become acquainted with General Electric's new silicon controlled rectifier.

Neither a transistor nor a rectifier, this remarkable device combines features of both. In the reverse direction it acts like a standard rectifier. But it also blocks forward current until either a critical breakover voltage is exceeded or a signal is applied to the third lead. Then it switches to a conducting state and performs exactly like a forward-biased silicon rectifier.

The controlled rectifier offers the circuit designer current ratings comparable to thyratrons, blocking voltages useful in industrial circuits, complete control of current turn-on without complicated circuitry, and switching speeds in microseconds.

While in many ways similar to the gas thyratron, the controlled rectifier provides faster firing and recovery times, very low forward voltage drop, higher efficiency, absence of filament with attendant warm-up delay and power consumption, and higher-temperature operation.

Check the sample ratings and suggested applications at left. Application data and specifications will be sent on request.



mum junction temperature is maintained at an extremely low level, making these devices ideal for low-leakage applications.

Minimum forward voltage drop and a hermetically sealed case have produced silicon rectifiers whose reliability exceeds all existing MIL specs. A comparative evaluation shows that G-E devices have the *highest* resistance to thermal runaway at maximum full load operating temperatures. Thermal shock and temperature-cycle tests show a closer match of materials for expansion and contraction, to protect against breaking the hermetic seal and shattering the silicon pellet.

Ask your G-E semiconductor representative for the "big news" on low-current silicon rectifiers. Or write for more information.

For fast delivery, lower prices, see your local G-E distributor!

A recent check shows that General Electric transistors and rectifiers are being sold by local tube distributors for within pennies of the factory price on quantities less than one hundred—with the important difference that transportation charges are prepaid when you buy from your local G-E distributor.

Increased stocking of semiconductors by local G-E distributors means you now have *one* source for all your electronic needs. General Electric distributors can also furnish you with a wide variety of technical information, application data and spec sheets.

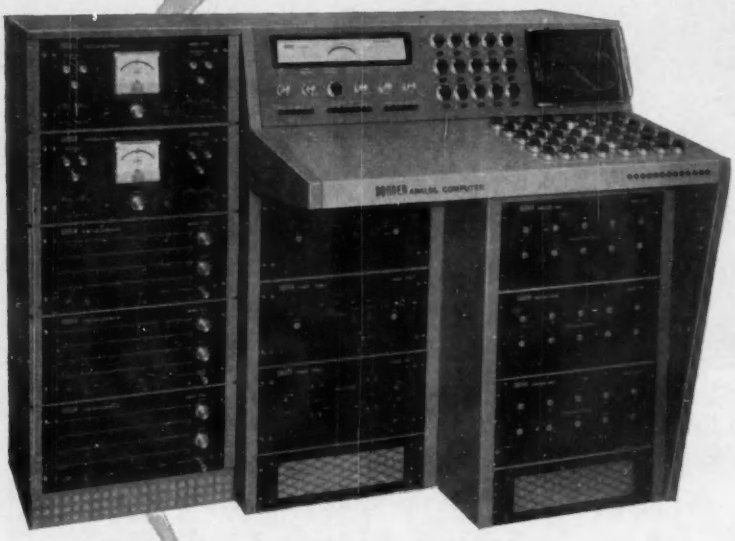
General Electric Company, Semiconductor Products Department, Section S16958, Electronics Park, Syracuse, N. Y.

GENERAL ELECTRIC

CIRCLE 116 ON READER-SERVICE CARD

CHOOSING THE RIGHT COMPUTER

An analog computer can be your basic tool for design, analysis, and control. You can solve a host of equations and simulate a variety of physical and chemical processes. You can even put the computer to work controlling the whole loop. You can do all these things quickly, conveniently and economically if you choose the right computer.



The Donner 3100 with non-linear equipment

WHAT ARE THE CRITERIA?

Functional versatility and operational convenience. In a great measure, the new Donner 3100 combines these key characteristics at a better price than any other computer on the market. Here are some of the things that add up to functional versatility and operational convenience:

- ★ *Built-in simulation board in addition to regular patch board.*
- ★ *The functions of the amplifiers are uncommitted.*
- ★ *The Donner is designed for expansion. You can start with as few as ten amplifiers.*
- ★ *Electronic multipliers to accommodate non-linear terms.*
- ★ *Electronic transport delay generators to simulate "dead time."*
- ★ *24-point function generators for synthesis of arbitrary functions.*
- ★ *Diodes to create limiting, backlash, and dead zone effects.*
- ★ *A true operating console.*
- ★ *Two or more computers can be interconnected.*
- ★ *Accommodates extra amplifiers at the simulation board for other uses such as special transfer functions.*

Prices for this high accuracy, medium size analog computer begin at $12,775 for a computer with 10 chopper-stabilized amplifiers and 20 coefficient potentiometers. $16,650 purchases this computer with 30 amplifiers and 40 pots. Special OEM prices. We have prepared an eight page data file describing the new Donner 3100. Yours for the asking. Please address Dept. 089.

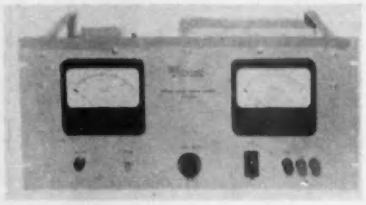
DONNER SCIENTIFIC COMPANY

CONCORD, CALIFORNIA

CIRCLE 117 ON READER-SERVICE CARD

frequency rating between and including 60 and 400 cycles will produce a dc output of 18 watts regulated to within 0.5 percent, at plus or minus 220 volts. At 60 cycles ripple is within 0.005 percent. Also available is a 6.3-vac, 5-amp output. Unit weighs 9 lb and measures 10¼ in. by 3½ in. by 4⅛ in.—Land-Air, Inc., Chicago, Ill.

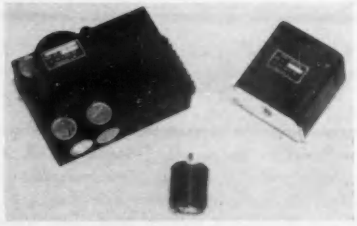
Circle No. **233** on reply card



STRAIN-GAGE SUPPLY

The Model 2-200 Transistorized Strain-Gage Power Supply provides 0 to 15 volts at 0 to 5 amp with less than 1 mv drift over a 24-hour period at constant temperature, and less than 0.001 percent per deg F with temperature changes. A 10-percent change in line voltage produces a change of less than 2 mv in the output, while a 1-amp change in load current produces a 1-mv change in output. Ripple is less than 1 mv peak-to-peak under all conditions of load. Circuit design prevents failure voltages greater than 20 volts.—Neff Instrument Corp., Pasadena, Calif.

Circle No. **234** on reply card



FOR INDUSTRIAL USE

The Model 1804-0100 power supply, top left in photo, provides 1 amp at 28 vdc for maximizing the output of a new 60-to-400-cycle servoamplifier. Overall package dimensions for power supply, amplifier, and motor, are 5⅛ in. high, 7 in. long, and 5 in. wide.—M. Ten Bosch, Inc., Pleasantville, N. Y.

Circle No. **235** on reply card

NEW BAILEY
Multi-Pointer Gage



...has twice as many indicators
...no taller than a telephone!

Now the popular versatile Bailey Multi-Pointer Gage has been reduced in size to conserve control panel space—without loss of easy *readability*.

Each new Multi-Pointer Gage Unit offers you these three choices to—

1. Measure and indicate draft, pressure, differential pressure and level.
2. Transmit above variables either pneumatically or electrically to remote indicators, recorders and/or controllers.
3. Receive and indicate any measured variables which may be transmitted pneumatically by standard SAMA ranges of 3-15 psig. or 3-27 psig.

FEATURES

Compact Size—Two large, easily-read 7″ scales in space only 4 inches wide.

Wide Range Selection—Standard ranges from 0-0.5 in. H_2O to 0-5000 psig available.

Choice of Standard Colors—Satin Black, Slate Gray, Moss Green, or Terra Tan may be selected as an exterior color at no additional cost.

Colored Scales—Scales available in white, red, green, blue, yellow, or orange.

Fluorescent Illumination—All gages have slideout unit containing bulb and starter for ease of maintenance.

Readily Accessible Adjustments—Zero adjustment made from front of gage. Other adjustments made from rear of gage.

Two-point Positive Mounting—Gage unit mounted with two clips . . . no holes to drill or studs to weld.

Unlimited Indications—Any number of basic two-indicator units may be placed side-by-side to provide indications of related factors. Each two-indicator unit is separatelymounted.

For additional information, call your local Bailey District Office, or write us direct. G47-1

See it at the ISA Show

Instruments and controls for power and process

BAILEY METER COMPANY

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BAILEY METERS

CIRCLE 118 ON READER-SERVICE CARD

Here's How DIT-MCO Analyzers Have Helped Leading Aircraft and Missile Manufacturers Solve Complicated Circuit Testing Problems:

- ☒ Human errors in testing
- ☒ Complicated test procedures
- ☒ Inconclusive test results

} Dit-Mco does the testing! Detects, classifies and locates every wiring flaw!

- ☒ Time-consuming hand tests — Cuts testing time up to 90%!

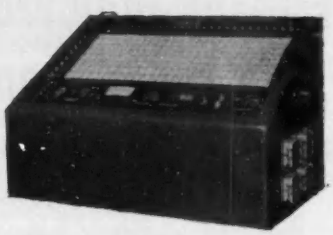
- ☒ Insulation damage due to chafing or clamping
- ☒ Wire shields shorted to conductors
- ☒ High resistance short circuits
- ☒ Other hard-to-find flaws

} Dit-Mco finds them all—even in multiple circuitry! Checks every wire against every other wire in the test circuit.

- ☒ Difficulty in locating errors in test circuit
- ☒ Time lost searching through wiring diagrams

} Exclusive matrix chart tells exactly where error is located!

These are just a few of the testing problems DIT-MCO has helped solve. Today, DIT-MCO tests assure the absolute accuracy of electrical systems in most major production and maintenance operations . . . more quickly and economically than was ever before possible. There's an automatic, universal, fast, versatile, simple to operate DIT-MCO Circuit Analyzer to meet every testing requirement. So—



if your product involves electrically complex circuitry

DIT-MCO Can Help You Make It Faster and Better at Less Cost!

Write today for complete information:

ENGINEERS:

DIT-MCO needs executive calibre sales and design engineers *right now!* Excellent opportunity with respected organization on the move. Work with key men in aircraft and missile industries. Write today!

DIT-MCO, INC.
Electronics Division

Box 09-32, 911 Broadway
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Partial List of DIT-MCO Users:

Aircraft Radio Corp. • AiResearch Manufacturing Co. • American Bosch Arma Corp. • American Machine & Foundry Co. • American Motors • Amphenol Electronics Corp. • Bell Aircraft Corp. • Bendix Aviation Corp. • Boeing Airplane Co. • Cessna Aircraft Co. • Chance Vought Aircraft, Inc. • Chrysler Corp. • Convair • Douglas Aircraft Co., Inc. • Dukane Corp. • Electronic Products Corp. • Fairchild Aircraft Division • Farnsworth Electronics Co. • Frankford Arsenal • General Electric Co. • General Mills, Inc. • Goodyear Aircraft Corp. • Hughes Aircraft • International Business Machines Corp. • Jefferson Electronic Products Corp. • Lockheed Aircraft Corp. • Martin, Baltimore • Minneapolis-Honeywell • Radio Corp. of America • Raytheon Manufacturing Co. • Sperry Gyroscope Co. • Temco Aircraft Corp. • Trans World Airlines • U. S. Naval Air Station Overhaul and Repair Depots • Western Electric Co. • Westinghouse Electric Corp.

CIRCLE 119 ON READER-SERVICE CARD

NEW PRODUCTS

FOR 0-300 V RANGE

Advantages claimed for a new transistorized, voltage-regulated power supply include excellent regulation, low ripple content, fast recovery time, good stability, and low output impedance. Designated Model SC 300-1, it delivers 0 to 1 amp at 0 to 300 volts, will regulate within 0.01 percent for line changes between 105 and 125 volts. Ripple is less than 1 mv, rms; recovery time, below 50 microsec. Unit also features an operating ambient temperature of 50 deg C and a temperature coefficient of less than 0.01 percent per deg C.—Kepco Laboratories, Inc., Flushing, N. Y.

Circle No. 236 on reply card

PLUS . . .

(237) A 24-32 vdc **transistor regulated supply,** from **Perkin Engineering Corp.,** El Segundo, Calif., provides transient-free dc power for driving static inverters and converters. . . . (238) Three types of controls are now available for the **induction voltage regulators** made by **General Electric Co.,** Schenectady, N. Y. . . . (239) **Yardney Electric Corp.,** New York, has developed a very-high-energy reusable **silver-zinc battery** with an exceptionally long wet-stand life. . . . (240) A high-power output unit has been added to the Series 600 line of completely automatic **voltage regulators** manufactured by **Tel-Instrument Electronics Corp.,** Carlstadt, N. J. . . . (231) **Globe Industries, Inc.,** Dayton, Ohio, announces a new **permanent magnet dc motor** that weighs only 1.7 oz and can produce starting torques up to 1.0 oz-in.

Circle No. 237, 238, 239, 240, or 241 on reply card

ACTUATORS & FINAL CONTROL ELEMENTS

THREE-WAY VALVE

Designed for aircraft and missile applications, the Model 65M44 three-way solenoid-operated valve measures 3.4 in. by 2.07 in. by 2.095 in., weighs only 0.77 lb, and has ¼ in. connections. It will handle pressures in excess of 3,000 psi. A new sealing de-



Barden Precision 206H5DB bearings as used in a computer storage drum

How to design **BARDEN** *Precision into your product*



Ball Quality Integrator, a Barden quality control instrument, measures performance characteristics of balls used in Barden Precision bearings. Developed by Barden for its own functional testing, the Ball Quality Integrator has set a standard for precision ball quality.

Effective computer storage drum performance depends on extreme accuracy in location of the rotating drum surface in relation to the magnetic pick-offs. Maximum allowable drum runout is commonly .0001".

The 206H5DB and other *Barden Precision* matched duplex bearings—including miniature sizes—provide the low eccentricity and low non-repetitive runout, as well as the rigidity, smoothness and long life demanded by this precision application.

You can design *Barden Precision* into your product by calling on Barden at the early design stages to help select the bearings you need to meet your specific demands for precision performance.

Your product needs *Barden Precision* if it has critical requirements for accuracy, torque, vibration, temperature or high speed. For less difficult applications, Barden *predictable* performance can cut your rejection rates and teardown costs.

From research and design, through quality controlled production, functional testing and application engineering, each *Barden Precision* bearing is planned for performance. *Barden Precision* means not only dimensional accuracy but performance to match the demands of the application.

THE BARDEN CORPORATION

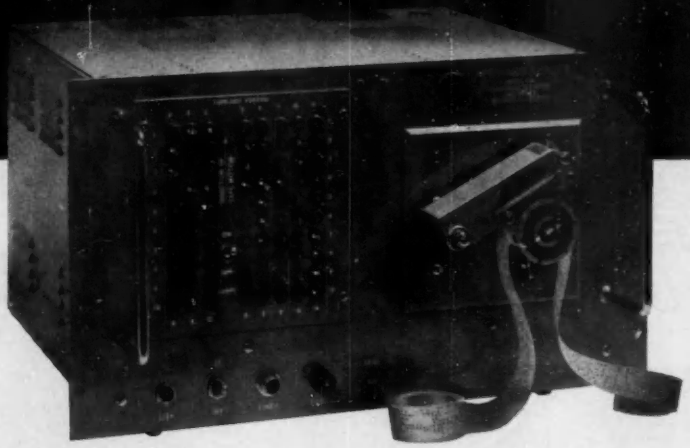
49 E. Franklin St., Danbury, Connecticut • Western office: 3850 Wilshire Blvd., Los Angeles 5, California

SPECIFY BARDEN PRECISION BALL BEARINGS FOR: INSTRUMENTS • COMPUTERS AND RECORDERS • AIRCRAFT ACCESSORIES • MACHINE TOOL AND TEXTILE SPINDLES • OTHER PRECISION APPLICATIONS

CIRCLE 120 ON READER-SERVICE CARD

TAPE READER

for Automation



80 information bits per step

A new concept in punched-tape readers, the CTI TAPE-ARD® READER combines the large information field of card readers with the ease of handling a fixed sequence of data provided only by tape. The reader is ideal for programming automatic operations and data handling.

80 bits of information are provided simultaneously at each advance of the tape by a unique reading head that covers a frame of 10 transverse rows of 8 holes each. A neon Verifier Panel shows actual reading, facilitates checking newly punched tapes. Tape advances on command.

TAPE PUNCH speeds programming

Electrically driven, the CTI TAPE-ARD® PUNCH features both keyboard operation and remote control of punching. Entire line of standard, 8-channel, 1-inch tape can be set up on keys which illuminate when selected. Keys can be cleared and corrected prior to pressing "Punch" button.

TAPE DUPLICATOR for copies and revisions

TAPE-ARD® DUPLICATOR coordinates the PUNCH with the READER to automatically reproduce tapes for use at several program stations. Can be stopped at any line for manually editing or inserting new information.

For complete information write to Dept. 14-9

Visit us at the
National Electronics Conference, Chicago, Oct. 13, 14, and 15

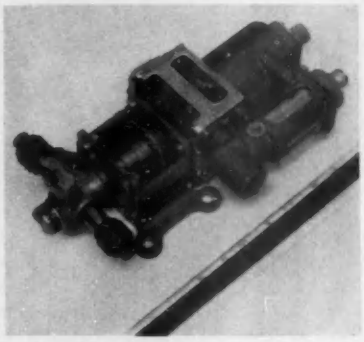
Engineers: Career opportunities are currently available at CTI.

CALIFORNIA TECHNICAL INDUSTRIES
DIVISION OF TEXTRON INC.
BELMONT, CALIFORNIA

CIRCLE 121 ON READER-SERVICE CARD

vice called a "captive" seal floats between valve seat and poppet, maintaining perfect balance regardless of pressure. — Robertshaw-Fulton Controls Co., Milford, Conn.

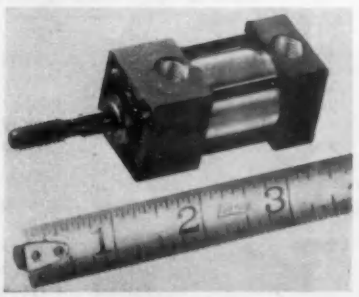
Circle No. 242 on reply card



FOR PRESSURE RATIOS

Equipped with a rectangular stainless steel diaphragm, this new pressure ratio controller has been designed for direct mounting on a jet engine. Pressure ratio error drives a 3,000-psi hydraulic servovalve which, in turn, provides power to operate the exhaust nozzle. Accuracy of the sensing mechanism is within ¼ percent over a pressure altitude range of 15 to 1. An integrally mounted electromagnetic valve permits remote resetting of the pressure ratio for excessive nozzle temperatures. Weight, including the hydraulic and electromagnetic valves, is less than 7 lb.—Consolidated Controls Corp., Bethel, Conn.

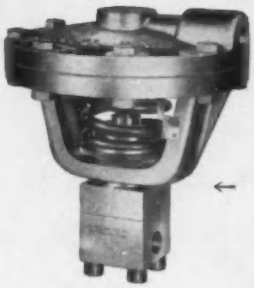
Circle No. 243 on reply card



TINY CYLINDERS

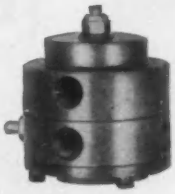
This new line of cylinders, offered in ¾-, 1-, and 1½-in. bore diameters, handles pressures to 2,000 psi, hydraulic. Mark A, for 200 psi air or 750 psi hydraulic, has a brass cylinder with black-oxide-treated steel heads,

MINIATURIZATION From Pilot Plant to Process



"BANTAM" 500 SERIES VALVE

Throttling "Bantam" Diaphram Control Valves for all standard control valve uses, Cv of 0.6 and below, up to 1000 psi and 500°F, characterized, renewable trim, 316 stainless steel and *Teflon* only wetted surfaces, low in hysteresis size and weight, 2000 series "Bantam" Control Valves available for on-off service.



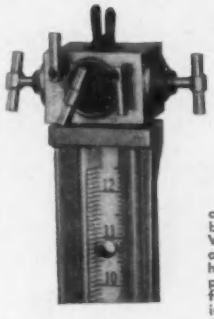
"MITE" 70

Pneumatic signal monitor. Embodies safety trip-out with manual or remote pneumatic reset. 250 PSI maximum pressure with trip adjustment for lock-up or vent from 1 to 100 PSI. Standard materials blue anodized aluminum. Other materials and models with integral two or three-way valves available.



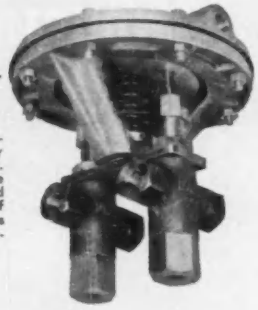
"DEMI" PACKLESS VALVE

For services when packing is a problem, manifolding of small valves in one unit at low cost. For services up to 750 psi and 500°F, screw, toggle, or diaphragm operated, the "DEMI" line is ideal for panel mounting up to five valves in one block.



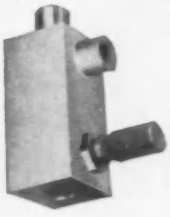
"DEMI 54"

5 Valve Manifold for integral mounting on cleanout type Manometer. Packless design, 2 shut off valves, one bypass valve, 2 vent valves. Other 3 or 5 valve models available with or without special manometer mounting.



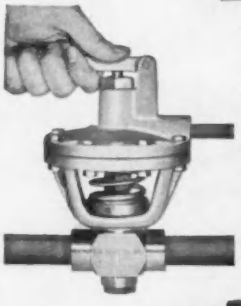
WHIFFLETREE OPERATOR

Two valves operated simultaneously by one operator. Valves may be globe or three-way and have a multitude of piping arrangements for mixing and routing applications.



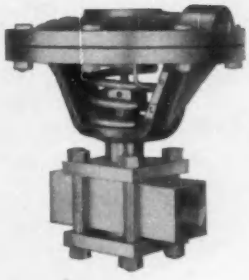
CONSTANT VOLUME REGULATOR

Fully automatic regulation provides constant volume output of gas or air regardless of fluctuating pressure drop. Capacity control by micrometer adjustment assures accuracy of desired output volume from 5.0 to 180 SCFH at pressure differentials from 1 to 25 PSI. Brass Body.



MANUAL RESET

Wherever control air on dangerout or toxic process flows must be blocked for safety, on air failure until manually reset, these valves insure against disaster. Standard sizes ¼" and ½" I.P.S.



AIR OPERATED CONTROL VALVE

Miniature diaphragm operated control valve. Barstock construction with bolted bonnet and blindhead. Connections from ¼" to 1" NPT. Cv. from .001 to 10.0. Direct or reverse acting operators for control applications. Extension bonnets for extreme temperatures available.



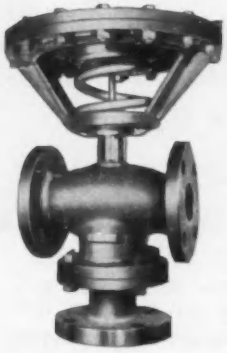
THROTTLING CONTROL VALVES WITH TOP MOUNTED MOORE POSITIONER

Compact, accurate and rugged. Light weight. Sizes from ¼" to 1" NPT. Flanged connections available. Barstock bolted bonnet, blindhead and body. Cv. from .001 to 10.0 with pressures to 1000 PSI.



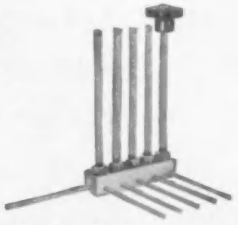
BLOCK VENT VALVE

3 balanced valves, 2 reverse acting and 1 direct acting, actuated by one operator. With 0 to 3 psi control air, the 2 reverse acting valves are closed, center valve vented. At 6 psi control air, all valves closed. At 12 to 15 psi, the 2 reverse acting valves are open and the vent valve is closed, allowing free flow through body. Design pressure 1000 psi. *Teflon*, Chevron packing. *Teflon* seating for tight shut off.



DIAPHRAGM OPERATED 3-WAY CONTROL VALVE

Aluminum diaphragm operator, stainless steel body and trim, *Teflon* packing with *Teflon* seating for tight shut off. Available up to 2", flanged or screwed.



MINIMUM VOLUME MANIFOLD

A compact manifold consisting of five packless valves having .0006 cubic inches volumetric displacement. Can be cam actuated for programming applications. Soldered, welded, tubing or NPT connections with applicable materials of manufacture for high temperature and high pressure service.

REPRESENTATIVES IN PRINCIPAL CITIES

Write us for complete technical information, or for the address of our representative in your area.

GEORGE W. DAHL COMPANY, INC. 86 TUPELO STREET, BRISTOL, R. I.

• • **Visit our Booth No. 1329, at the ISA Show, Sept. 15-19** • •

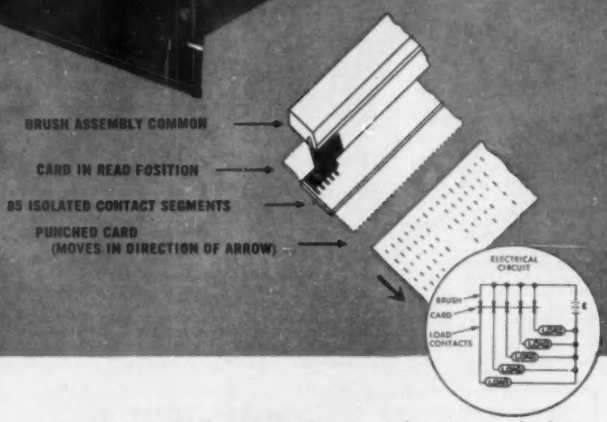
NOW! Direct Control from

New Simplified Electro-Mechanical PUNCHED CARD and TAPE Programmer

by INDUSTRIAL TIMER CORPORATION



- No coding or decoding required
- Up to 85 control units
- Unlimited number of functions
- Permanent Mylar card & tape



The Industrial Timer Programmer was developed to fill the great industrial need for a simple and dependable method of applying automatic control to a majority of manufacturing and operational processes. Its multi-channel control is capable of operating independently of complicated coding and decoding, sensitive translation apparatus, and extensive memory systems.

Here is an electro-mechanical card reader that directly controls as many as 85 individual load circuits through as many as 30 functions. Program data is punched on a 5″ x 9″ permanent card. Circuit completion is accomplished by an electrically common brush wiping against individual contact segments exposed through the punched hole. This is schematically shown in the accompanying diagram; the card carriage advances through the program and can be reset at the end of the 30th step, or from any intermediate step as required. Any external switch closure will advance the program card.

*Reg. T.M. DuPont

CIRCLE 123 ON READER-SERVICE CARD

Programmer to Process



The Punched Tape Programmer is very similar to the Punched Card Programmer but utilizes a 9″ wide tape rather than the 5″ x 9″ card. The tape is constructed of three laminations, the two outside or exposed surfaces are an anti-static paper, and the center laminate is composed of an extremely durable Mylar* plastic. There are 64 steps to each footlength of tape, thereby providing a quantity of steps limited only by the length of the tape.

As in the Punched Card Programmer, 85 possible channels are available. The tape reading mechanism consists of an electrically common brush assembly providing a complete circuit to each exposed contact segment.

The tape is driven from step to step by means of a motor and a sprocket drive assembly. Contact wipe is provided during each step movement insuring positive circuit completion. Additional circuit control is provided so that the tape can be returned to any point in the program, or to re-cycle as required.

VERSATILITY OF APPLICATION

Since the Punched Card and Tape Programmers operate from any switch closure they are easily adapted to a variety of bases; for example, analog, digital, temperature, feed-back, photoelectric, limit switch, manual, time, and many others.

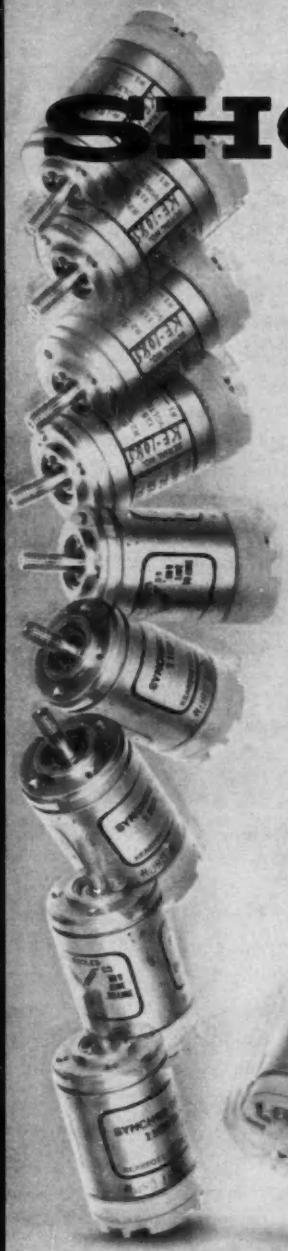
The Punched Card and Punched Tape Programmers have been designed to provide the utmost in flexibility. Each unit can easily be modified or re-designed to meet your particular requirements. A few applications are: pre-flight testing of missile and aircraft auto pilots, count down and missile firing controls, reversing mill operation, quality control and life testing of electronic components, automatic machine tool operation, automatic molding and curing, automatic positioning, and many other multi-circuit controls.

If you want further information, let us know and we will have one of our engineers contact you immediately. Industrial Timer Programmers will be featured at the ISA show in Philadelphia at Booth 1253.

INDUSTRIAL TIMER CORPORATION

1419 McCARTER HIGHWAY, NEWARK 4, N. J.

Precision Components...another Kearfott capability.



SHOCK

Shock, vibration, and high-temperature problems have been solved in Kearfott Precision Synchros, Servomotors, and Motor-Generators. Widely used in missiles and high-performance aircraft, they withstand shock of up to 50-Gs and still provide consistent performance.

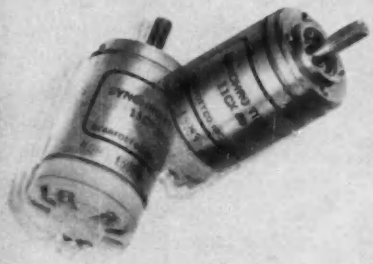
200°C temperature and 2000-cps vibration are taken in stride by these precision components. In addition to their environmental capabilities, small size, light weight, and corrosion resistance, Kearfott components provide unmatched accuracy.

Synchros: available in sizes 25 through 8, with errors as low as 20 seconds.

Servomotors: available in sizes 18 through 8. Wound for transistorized amplifiers.

Motor-Generators: available in sizes 15 through 8, linearity 0.01%.

Write today for detailed technical literature.



Engineers: Kearfott offers challenging opportunities in advanced component and system development.

Kearfott

GENERAL PRECISION EQUIPMENT CORPORATION GPE

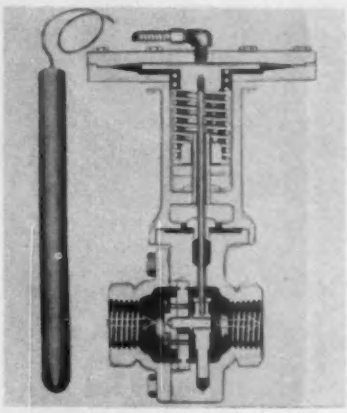
KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
A Subsidiary of General Precision Equipment Corporation
Sales and Engineering Offices: 1378 Main Ave., Clifton, N. J.
Midwest Office: 23 W. Calendar Ave., La Grange, Ill. South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

CIRCLE 124 ON READER-SERVICE CARD

NEW PRODUCTS

piston, and tie rods. Mark H, for 2,000 psi hydraulic, has all-steel parts. Both series use replaceable O rings for static and moving seals.—Control Line Equipment, Cleveland, O.

Circle No. **244** on reply card

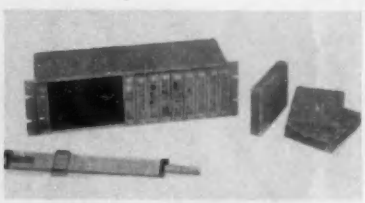


PLASTIC COATED BULB

Thermal systems with sliding-gate control valves now feature plastic coated sensing bulbs that provide economical corrosion resistance. Bulbs are suitable for temperatures up to 185 deg F; valves are available in sizes from ¼ in. to 2 in. Capillary tubing, also plastic coated, is furnished in either 8- or 15-ft lengths.—Jordan Industrial Sales Div. of OPW Corp., Cincinnati, O.

Circle No. **245** on reply card

RESEARCH, TEST & DEVELOPMENT

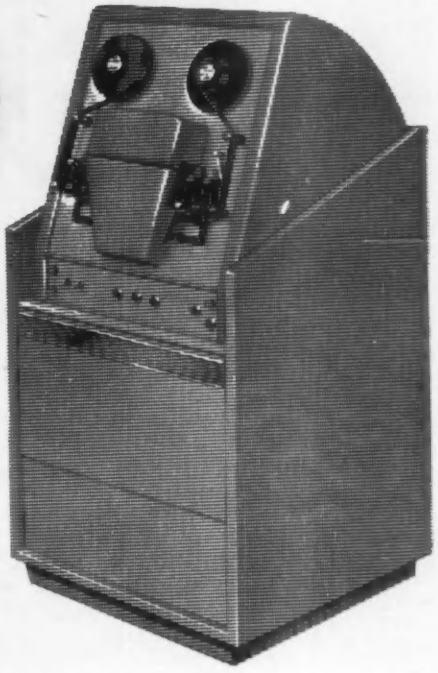


FOR DIGITAL SYSTEMS

A pluggable, pin-jack system easily combines these high-speed, transistorized "Data Blocs" into a variety of special test equipment. Assemblies that can be made up in a matter of

Burroughs Photoreader

reads this many characters in one second!

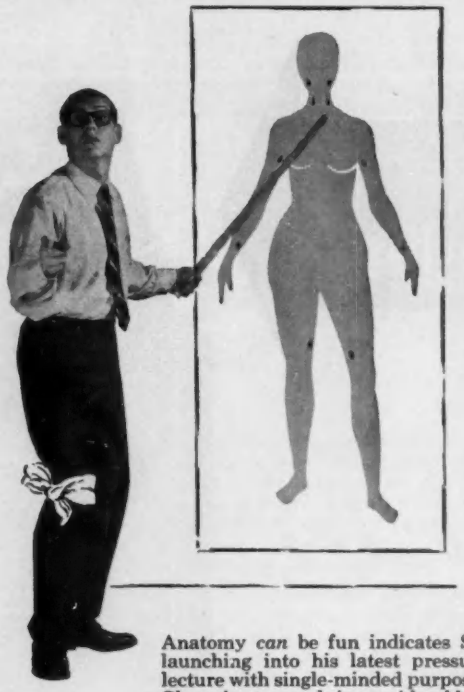


1,000 CHARACTERS PER SECOND! And it stops on a single character... then reads the next character within five milliseconds after restart! The new Burroughs Photoreader by ElectroData Division of Burroughs Corporation is now commercially available... the finest precision paper tape reader of such high-speed performance being offered as a component. Speed of the Photoreader introduces a new high in computer-time efficiency to business and scientific data processing. Its instantaneous stop-ability simplifies computer techniques... also brings faster, more efficient operation to missile test checkout, fire control systems, equipment test procedures and machine automation. The Photoreader is adaptable to standard-width tape, from five to eight level code. Economic plastic reels are available in two sizes for tapes of 350 or 700 feet (40,000 or 80,000 Characters). Automatic rewind and end-of-tape sensing; true straight-line loading and drift-free design. Developed as an input unit for the new Burroughs 220 data processing system, the Photoreader is also available as a component for mounting in any standard 19″ cabinetry. It may also be ordered already housed in the Burroughs 220 cabinet, as pictured. For complete details write

Burroughs Corporation
ELECTRODATA DIVISION
PASADENA, CALIFORNIA

stops on a single character!

On display ISA Show – September 15-19 – Booth #1045



pressure measure

Anatomy *can* be fun indicates Sherman, launching into his latest pressure point lecture with single-minded purposefulness. Sherm's approach is considerably less enlightening than our more academic means of measuring pressure. Example: Rocketdyne, a division of North American Aviation, Inc., applauds (quietly) its success in measuring rocket combustion chamber pressure with BJ Electronics' Single Point Data Processing System.

Essential is our Vibrotron® Pressure Transducer and Amplifier which comprise an oscillator sub-system. The transducer's fine tuned wire stretched in a magnetic field controls operating frequency; combustion chamber pressure variations change the wire's resonant frequency, hence the oscillator system output. A frequency output modulated by input pressure is thus accomplished.

Readout instrumentation converts the output to numerical representation of pressure, providing scale adjustment, linearization and zero suppression in the process. Visual display and/or printed tape record test results.

Happily for you, our data acquisition systems can be built to process any number of inputs from pressure, temperature, frequency and millivolt signals. For example the new D311 Single Point Data Process System (shown lower right) accepts Vibrotron Transducer output and provides visual numerical output related to pressure as actual value, % of full scale or any fraction thereof. We can help you. Our technical bulletins attempt to substantiate this premise. Write for yours.



Upper: Rocketdyne System.
Lower Right: New D311 Single Point Data Processing System.

BJ ELECTRONICS
B-W
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BJ ELECTRONICS
BORG-WARNER CORPORATION
Reliability you can count upon

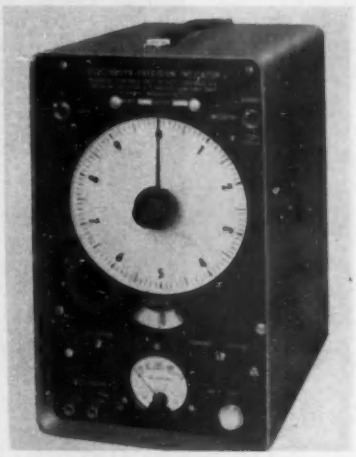


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EXPORT SALES: BORG-WARNER INTERNATIONAL CORP., CHICAGO, ILLINOIS

CIRCLE 126 ON READER-SERVICE CARD

minutes include shift registers, counters, pulse generators, pattern generators, and experimental prototypes. Marginal checking is a standard feature on all units.—Harvey-Wells Electronics, Inc., West Roxbury, Mass.

Circle No. **246** on reply card



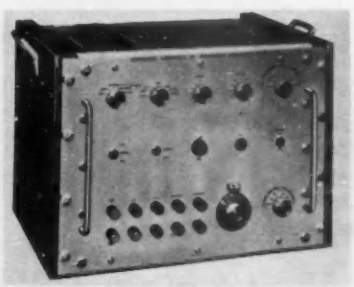
TRANSDUCER CALIBRATOR

Called the Model 850 Precision Indicator, this instrument provides a fast, accurate means for calibrating pressure transducers. Used with standard pressure transmitters, it becomes a secondary reference standard to which the equipment under test is compared.

Characteristics:

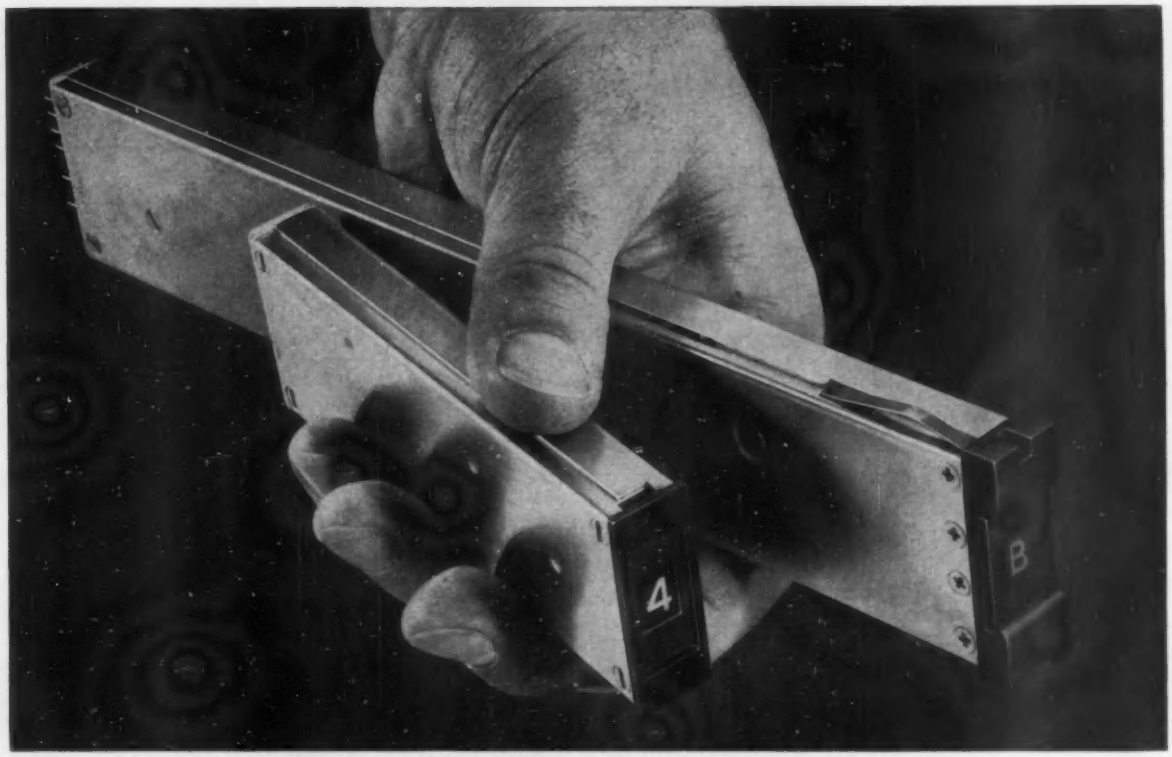
Accuracy: within 0.25 percent full-scale
Linearity: within 0.15 percent
Optical resolution: 0.05 percent
Reproducibility: within 0.1 percent
—Norwood Controls, Norwood, Mass.

Circle No. **247** on reply card



FUNCTION GENERATOR

The Servomex waveform generator for testing servos and automatic control systems, particularly nonlinear systems, produces a wide variety of elec-



Digital indicator (left) can display a possible 16 characters and is about half the size of the Alpha-numerical indicator (right) which displays 64 characters.

UNION INDICATORS
permit direct readout of binary data

UNION Digital and Alpha-numerical indicators are controlled by binary code signals employing a minimum number of control wires, and respond to simultaneous binary switching combinations.

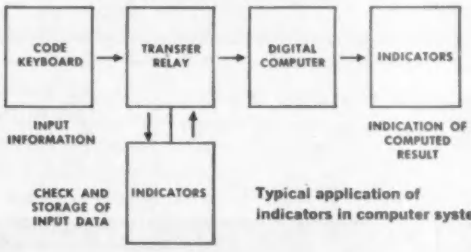
These indicators are electro-mechanical, D.C.-operated, readout devices for displaying characters in accordance with a predetermined code. The character display may be made to suit user's requirements.

Indicators are designed for plug-in mounting in a row so that data or messages of any desired length can be stored, displayed or transmitted at will. The indicators can be applied to the output of digital computers, teletype receiving equipment in conjunction with a buffer storage unit, telemetering systems, or wherever data needs to be displayed.

Two important features of these indicators are their inherent storage and transmitting characteristics which provide for data entry and retransmission. The indicators can be used to accept data from a source, free the source for other programs, and disseminate the data from one indicator to another as required. For each binary bit stored, an external relay can be eliminated.

UNION indicators have provided economic and reliable advantages in data display applications associated with Air Traffic Control, Navigation, Telemetering, Fire Control and similar Airborne and Surface Instrumentation displays.

Write for Bulletin No. 1015 for complete information.



Typical application of indicators in computer systems.

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

CIRCLE 127 ON READER-SERVICE CARD

AN UNPRECEDENTED EXPERIMENTAL OFFER!

A standard DC 100-microampere **METER-RELAY** at virtually **HALF PRICE!**

Limit is 2
We pay the freight!
Immediate air delivery

$27.50 each
Standard Price $53.50



• Every engineer who needs or wants our versatile, most-used, No. 461-C locking-contact Meter-Relay for use or experiment ...but never ordered because of price or wait...can now order at *half-price* and get *immediate delivery* by return air mail!

D'Arsonval might say:



"Formidable! Incroyable! Épatant!"

Translation:

"It is a matter of great amazement to me that Assembly Products can manufacture such a superb version of my sensitive electric meter

...then add the ingenious adjustable contact within the meter

...then insure the concise, reliable contact action for 10 to 20 million cycles by means of the unusual locking-unlocking coil

...then develop the refinements which make this magnificent device capable of indicating and controlling an infinite variety of electrical, physical and mechanical actions

...then build a substantial business by direct sales to the user at most reasonable prices

...enjoy unqualified success

...AND THEN MAKE THIS UNUSUAL OFFER!"

"Could I write, I would."

AT THE PHILADELPHIA INSTRUMENT SHOW: Sold over our counter at the same $27.50!

OFFER ENDS OCTOBER 1, 1958 (Order postmark date)

ALSO REQUEST **FREE CATALOG** OF COMPLETE METER-RELAY LINE

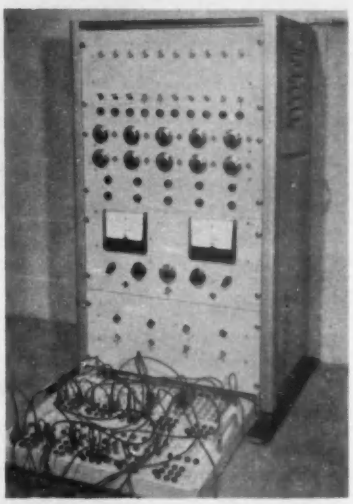
api **Assembly Products**
75 Wilson Mills Road, Chesterland, Ohio
Phone: HAmilton 3-4436
HAmilton 3-4446

CIRCLE 128 ON READER-SERVICE CARD

NEW PRODUCTS

trical test signals over a wide range of frequencies. Waveforms include sine, square, triangular, sawtooth, trapezoidal, and sine-squared. Square waves and pulses can be generated with durations of from 100 μsec to 1,000 sec and sine wave frequencies can be varied from 500 cps down to 0.0005 cps. Design also permits the generation of one complete cycle or one-half cycle of any of the above waveforms. Amplitude is variable from 100 μv to 150 volts peak-to-peak in six ranges.—Servomex Controls, Ltd., Sussex, England.

Circle No. 248 on reply card



ANALOG COMPUTER

This Model AC-2 desk-top analog computer features a self-contained power supply and built-in fan and filter. Its schematic-type problem board uses colored jacks and block diagram markings to facilitate problem setups. A very useful "hold" feature permits a problem to be stopped at any point so that voltages may be checked. Each of 10 operational amplifiers may be used as an adder, integrator, or sign changer.—Engineering Specialty Co., Salt Lake City, Utah.

Circle No. 249 on reply card

PLUS . . .

(250 A fully automatic, **electromechanical scanner**, by **ATOMation Inc.**, Los Angeles, Calif., is designed for applications in field plotting, film scanning, three-dimensional chromatograph scanning, and other measure-



OUT OF RESEARCH...NEW PRODUCTS FOR AMERICA

Avco Research and Advanced Development announces the availability of . . . .

truly new, truly advanced equipment for industrial and military research programs . . . equipment that will greatly improve existing techniques and enable achievement of research and development objectives.



Instrumentation—Avco's Kerr Cell Shutter, representative of our advanced instrumentation, is an extremely compact unit capable of precision exposures from 0.1 microsecond down to 0.01 microsecond.

Data Processing—Avco's Transistorized Building Blocks provide a new dimension to designers of special purpose control devices.

Environmental Equipment—Avco's Acoustic Noise Generator simulates, in the laboratory, noise produced by missile and jet engines.

Only creative scientific thinking and the most progressive practical engineering could yield so unique an equipment program. Other current projects of the Research and Advanced Development Division of Avco . . . one of America's largest, most complete technical organizations . . . promise to yield equally striking results.

Further announcements will be forthcoming over the next several months. We intend to supply American industry with the products of research.

AVCO

Research & Advanced Development

Marketing Department,
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SEE AVCO'S HYPERSONIC INSTRUMENTATION, BOOTH 1618, ISA EXHIBIT, PHILADELPHIA, SEPT. 15-19



The standard steppers shown to the right above are now available at your nearby franchised Guardian distributor located in principal areas of the United States and Canada. Write direct to Guardian for details about the On/Off Relay and Programmer.

GUARDIAN® Steppers are the ultimate for integrated control of your product. They take over and handle perfectly any and every job of stepper control, save space, abolish excess circuitry and sharply depress your costs. Guardian is ready to draw on more than twenty-six years of stepper design and application experience to recommend and supply the correct stepper to meet your exact requirement. If it's a Ratchet, Interlock, Snap-Action On/Off Relay, a standard relay or special control, Guardian makes it, too!

We Invite Your Inquiry.

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MANUFACTURING COMPANY
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CIRCLE 130 ON READER-SERVICE CARD

NEW PRODUCTS

ment, control, or data reduction problems. . . . (251) **Aerovox Corp.**, New Bedford, Mass., has introduced a line of 10 new **decade boxes** for laboratory applications. . . . (252) For accurate testing of power transistors, **Armour Electronics, Inc.**, Van Nuys, Calif., offers the Model T-340 **test set**. . . . (253) **A precision millivolt per volt standard** for convenient calibration and maintenance of strain-gage systems is available from **Bytrex Corp.**, Newton, Mass., for $165. . . . (254) **Electro-Measurements, Inc.**, Portland, Ore., claims that its Model 230-R **precision Wheatstone bridge** is accurate to within 0.02 percent for measurements between zero and 12,000 megohms.

Circle No. 250, 251, 252, 253, or 254, on reply card

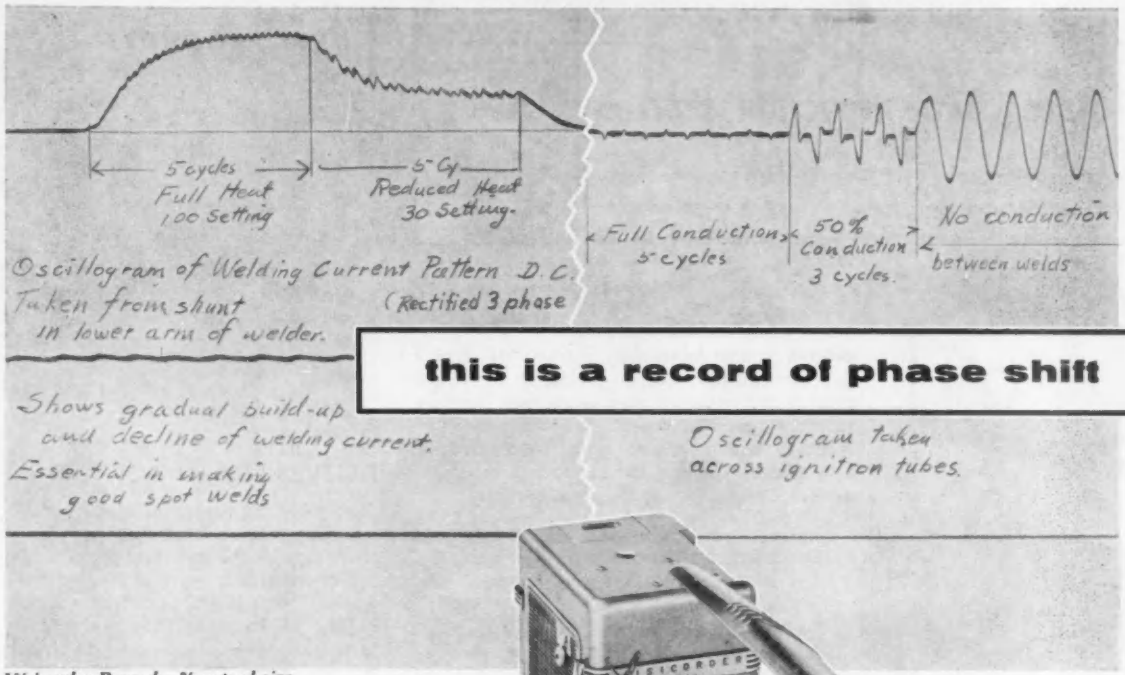
COMPONENT PARTS



PUTS OUT 0.4 WATTS

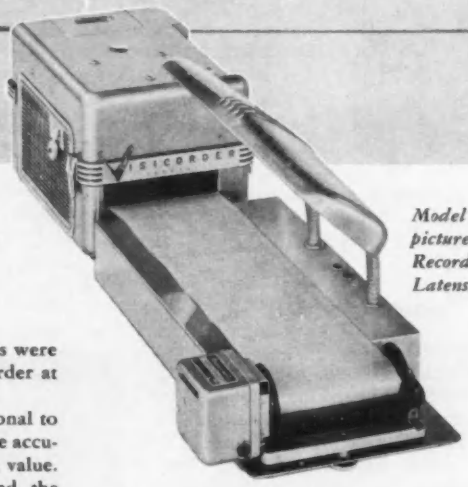
Recommended for aircraft, missile, and industrial applications, the Model 701 sensitive relay magnetic amplifier operates on less than 3 μwatts of dc control power and delivers 0.4 watts of output power. The unit permits accurate and reliable operation of small-power relays from low-energy sources such as photoelectric cells, null detectors, thermocouples, etc. Designed to operate from 26 volts at 400 cps, it weighs less than 6 oz and is hermetically sealed.—Acromag, Inc., Detroit, Mich.

Circle No. 255 on reply card



this is a record of phase shift

Visicorder Record — ⅓ actual size



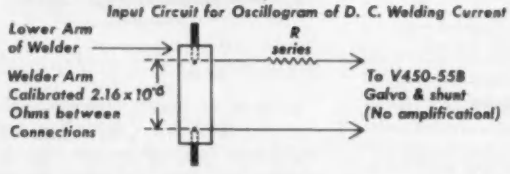
Model 906A Visicorder pictured with Record Takeup and Latensifier Unit.

These welder phase-shift heat-control patterns were directly recorded with a Honeywell 906 Visicorder at Bristol Aircraft (Western) Limited in Winnipeg.

Since the welding heat generated is proportional to the square of the current value, phase shift must be accurately controlled in order to determine the heat value. If the phase shift dial is not accurately calibrated, the result is too much or too little heat, and a poor weld.

In this application, the Visicorder is an essential guide to accurate calibration, since ink-type recorders do not cover the sensitivities and frequencies needed and an oscilloscope would present a continually changing pattern since most recording periods are less than 10 cycles. The directly-recorded Visicorder patterns allow a convenient study of the exact time when the current wave form was being cut off.

Here is the circuit used in this test.



The Honeywell Visicorder is the first high-frequency, high-sensitivity direct recording oscillograph. In laboratories and in the field everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

The new Model 906A Visicorder, now available in 8- and 14-channel models, produces longitudinal grid lines simultaneously with the dynamic traces, time lines, and trace identification by means of new Accessory units.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

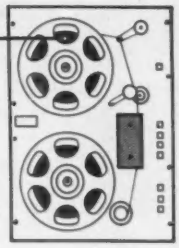
Honeywell

Industrial Products Group

Reference Data: Write for Visicorder Bulletin

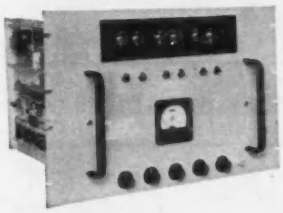
Minneapolis Honeywell Regulator Co., Industrial Products Group, Heiland Division, 5200 E. Evans Avenue, Denver 22, Colorado

RAPID ACCESS



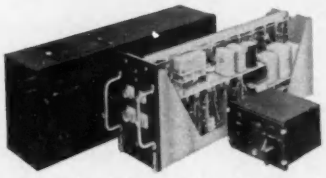
IN ANALOG DATA REDUCTION SYSTEMS

Three companion units by Hycon Eastern provide automatic indexing and high-speed access to selected data in multi-channel magnetic tape instrumentation systems.



For Tape Indexing

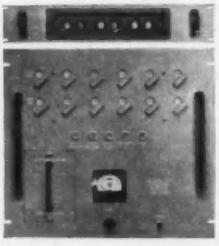
DIGITAL TIMING GENERATOR, MODEL 201, generates numerically coded timing signals which are recorded on magnetic tape throughout the data recording periods, providing a precise digital index in terms of elapsed time. The Generator also visually displays the exact time in hours, minutes and seconds as illuminated digits.

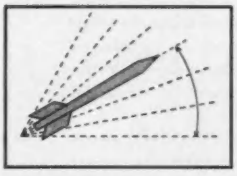


DIGITAL TIMING GENERATOR, MODEL 206A, FOR AIRBORNE APPLICATIONS is a militarized version of Model 201. A Remote Control Box contains Power off-Standby-Operate Switch, the Digital Clock Set, and the Time Display. Completely transistorized, Model 206A includes a binary coded decimal system although other timing formats are available to meet customer requirements. Weighing only 13 pounds, Model 206A is stable to 1 part in 100,000 giving an accuracy of ± 1 second in 1 day's time.

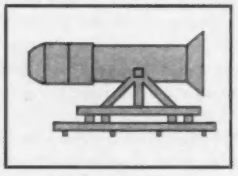
For Tape Search

MAGNETIC TAPE SEARCH UNIT, MODEL 202, operates during data reduction periods. On the basis of time indices recorded on the tape by the Digital Timing Generator, this instrument automatically locates and selects for controlled playback the tape data included between a "sequence start time" and a "sequence end time" specified by panel dial settings. The time index is visually displayed as illuminated digits on a small separate panel which may be remotely located for convenience. Model 202 may be modified to search for timing formats other than those originated by Model 201.

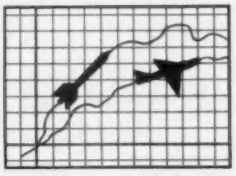




WIND TUNNEL TESTING
Pressure and temperature data of missiles are referenced to angle of attack. Model 201 records on tape a digitized position signal for each new angle of attack.



JET ENGINE TESTING
Digital Timing Generator, Model 201 synchronizes all data receiving equipment. Its output can be piped to multiple test cells and control rooms simultaneously.



MISSILE AND AIRCRAFT TESTING
Model 206A generates timing signals simultaneously with other flight test data. Model 201 generates a timing code format for synchronizing ground station recordings.

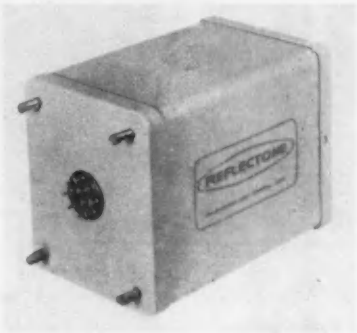
Write for Technical Bulletin TSG

HYCON EASTERN, INC.

75 Cambridge Parkway Dept. J Cambridge 42, Mass.

CIRCLE 132 ON READER-SERVICE CARD

NEW PRODUCTS



DELIVERS UP TO 10 WATTS

Shown is a high-speed magnetic servoamplifier that operates from standard single- or double-speed synchro control transformers, or from bridge networks. The unit will drive a wide variety of standard, low-impedance, two-phase servomotors, and deliver up to 10 watts mechanical output. Shockproof and hermetically sealed, it will develop 30 volts for a 1-volt input and 70 volts for a 2.25-volt input. The entire system operates from a 115-volt, 60-cycle source.—The Reflectone Corp., Stamford, Conn.

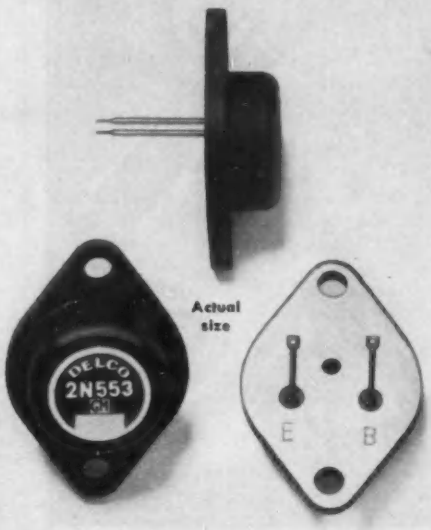
Circle No. 256 on reply card



SMALLER AND LIGHTER

Two new constant-voltage transformers in 2- and 3-kva capacities feature significant reductions in size and weight and new variations in circuit connections. Photo above shows an end view of the 3-kva model. Terminal connections are made to low-resistance, screw-pressure contacts mounted on a molded phenolic terminal strip. This arrangement permits three-wire 118/236-volt loading. Regulation is within 1 percent.—Sola Electric Co., Chicago, Ill.

Circle No. 257 on reply card



ANNOUNCING...

the newest addition to the Delco family of PNP germanium transistors! It's ideally suited for high-speed switching circuits and should find wide use in regulated power supplies, square wave oscillators, servo amplifiers, and core-driver circuits of high-speed computers. It's the 2N553!

NEW HIGH-FREQUENCY POWER TRANSISTOR BY DELCO

No other transistor offers so desirable a combination of characteristics for applications requiring reliability and consistency of parameters.

TYPICAL CHARACTERISTICS T = 25°C unless otherwise specified

Collector diode voltage V_{CB} (V_{EB} = −1.5 volts)	80 volts maximum
Emitter diode voltage V_{EB} (V_{CB} = −1.5 volts)	40 volts maximum
Collector current	4 amps. maximum
Base Current	1 amp. maximum
Maximum junction temperature	95°C
Minimum junction temperature	−65°C
Collector diode current I_{CO} (V_{CB} = 2 volts)	12 μa
Collector diode current I_{CO} (V_{CB} = −60 volts)	0.5 ma
Collector diode current I_{CO} (V_{CB} = −30 volts, 75°C)	0.5 ma
Current gain (V_{CE} = −2 volts, I_C = 0.5 amp.)	55
Current gain (V_{CE} = 2 volts, I_C = 2 amps.)	25
Saturation voltage V_{EC} (I_B = 220 ma, I_C = 3 amps.)	0.3
Common emitter current amplification cutoff frequency (I_C = 2 amps. V_{EC} = 12 volts)	25 kc
Thermal resistance (junction to mounting base)	1° C/watt

BRANCH OFFICES

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

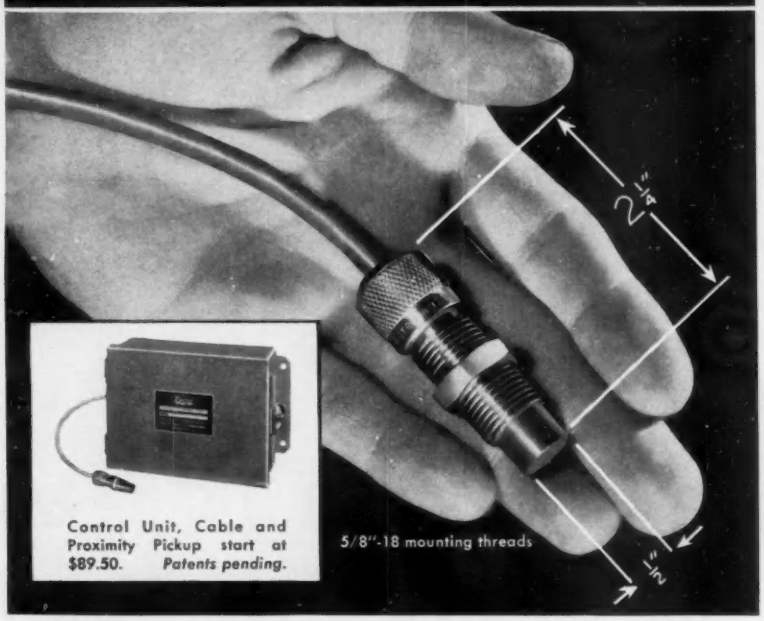
Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

DELCO RADIO Division of General Motors
Kokomo, Indiana

CIRCLE 133 ON READER-SERVICE CARD

Electro ELECTRONIC EQUIPMENT

First in Proximity Pickups



Solve your metal control problems with this low cost proximity pickup

Compare these advantages over other proximity devices

Flexible . . . Detects both ferrous and non-ferrous metals. Sensitive to very thin metal pieces, such as aluminum foil. Does not attract or hold ferrous chips.

Compact . . . Only the small Pickup need be located in the work area. Control Unit can be located up to 50 feet or more away.

Economical . . . Low replacement cost for Pickup ($13.50).

Rugged . . . Sealed Proximity Pickups for water and oil environments.

Proven Reliability . . . Three years continuous use in automotive industry.

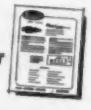
Qualified . . . Meets JIC requirements.

Other "plus" advantages

Versatile . . . Wide variety of Proximity Pickups available for detecting metal objects at clearances in excess of 6 inches. Suitable Hollow Coil or "pass through" type Pickups available for detecting or counting small metal parts of various sizes.

Practical . . . Associated Control Unit contains relay output for direct operation of motor controls, solenoids and electric counters.

Write or Phone for Bulletin and Name of Nearest Field Engineer



6088

Electro ELECTRONIC EQUIPMENT

Sensing Elements for Control Counting Speed and Displacement Measurements

ELECTRO PRODUCTS LABORATORIES
4501-C N. Ravenswood, Chicago 40, Ill., LOngbeach 1-1707
Canada: Atlas Radio Ltd., Toronto


D.C. Power Supplies


Magnetic Pickups


Sonometer


Dynamic Micrometer

CIRCLE 134 ON READER-SERVICE CARD

NEW PRODUCTS

FASTEST SERVOMOTOR

The SM-420 Size 8 servomotor is said to respond to minimum control signals eight times faster than similar units. Features include small size, light weight, and stainless steel housing, shaft, and bearings.

Characteristics:

Rotor inertia: 0.1 gm cm^2
Stall torque: 0.25 oz-in.
Acceleration at stall: 170,000 rad per sec^2
Weight: 1.1 oz
—Beckman/Helipot Corp., Newport Beach, Calif.

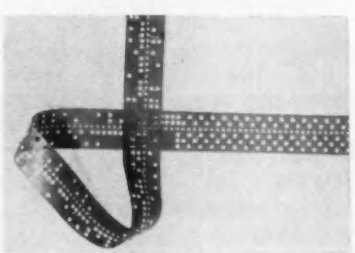
Circle No. 258 on reply card

PLUS . . .

(259) A new **linear motion potentiometer,** developed by **Bourns Laboratories,** Riverside, Calif., features compact, tubular configuration which permits installation inside an actuator. . . . (260 A highly sensitive proportional **magnetic amplifier** that provides reliable temperature control in industrial applications has been introduced by **Magnetic Controls Co.,** Minneapolis, Minn. . . . (261) **Allen-Bradley Co.,** Milwaukee, Wis., produces a line of **precision resistors** featuring a metal-alloy-grid resistance element. . . . (262) **Pic Design Corp.,** East Rockaway, N. Y., offers a variety of newly designed **magnetic clutches and clutch brakes** in Mark 14 or Size 11 frame diameters.

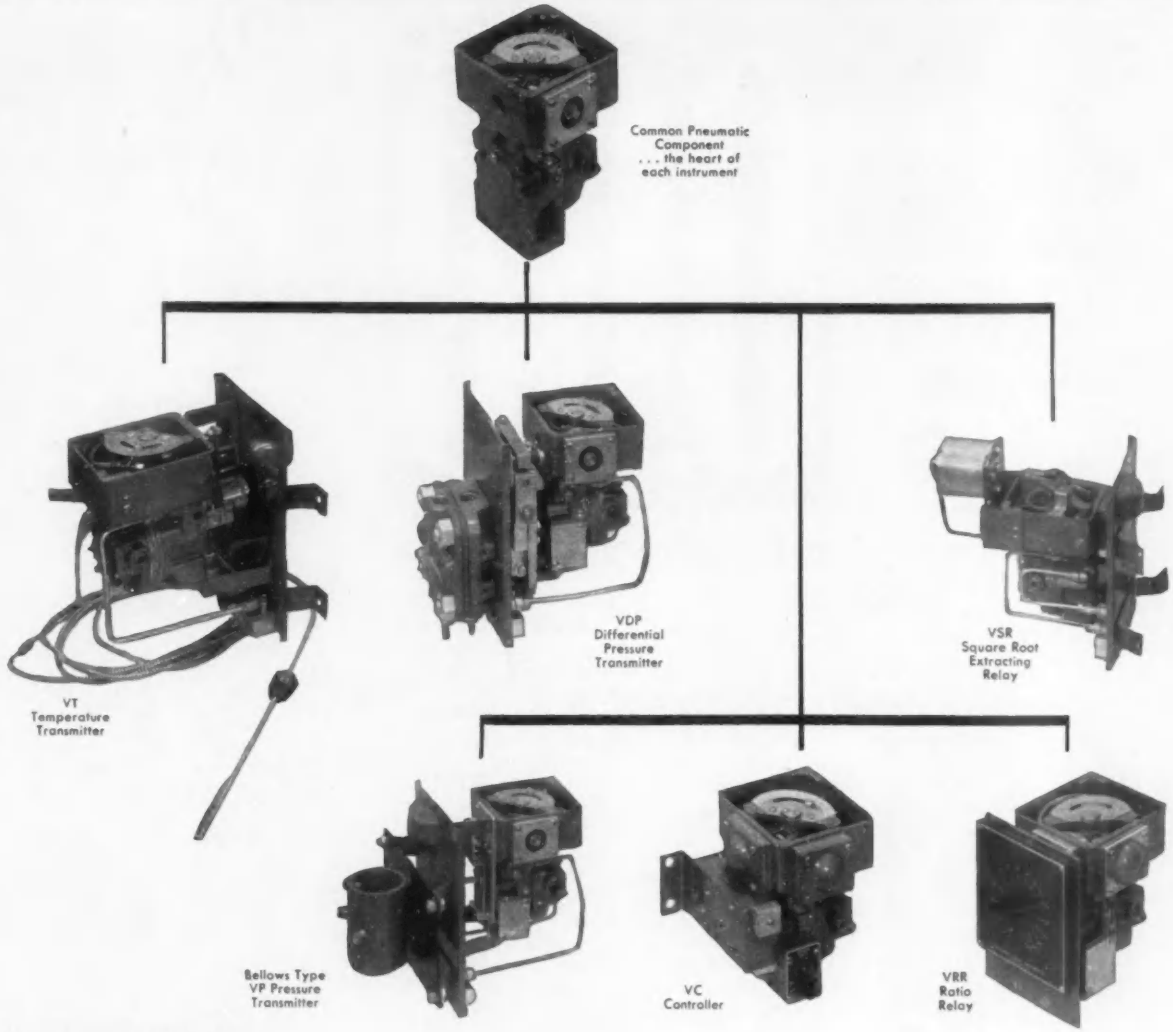
Circle No. 259, 260, 261, or 262 on reply card

ACCESSORIES & MATERIALS



PROGRAM TAPE

This new control tape is designed for use on tape-controlled automatic pro-



Rockwell-Built

Republic Vector Series Instruments

serve any process, cut costs too!

You can save substantial money when your control systems are based on Republic's Null-Balance Vector instruments. Each has as its "heart" an identical pneumatic component, with obvious advantages. Among these are interchange of parts, even among instruments performing entirely different functions. Besides involving a minimum spare parts inventory, this feature greatly simplifies personnel training.

Components shown demonstrate the depth of the Republic line. Differential pressure transmitters with 20-to-1 range adjustment . . . temperature transmitters with 10-to-1 range adjustment . . . pressure transmitters of ±.5% accuracy. We have ratio, totalizing, multiplying, squaring and square root extracting relays. Our all-purpose controllers feature proportional band adjustment of 2% to 500% and reset adjustment from 0.1 to 50 repeats per minute.

The Republic Engineer in your area will be glad to work with you on any control or measurement problem. Sales offices in principal cities throughout the United States and Canada. Call or write—with no obligation, of course.

REPUBLIC FLOW METERS CO.

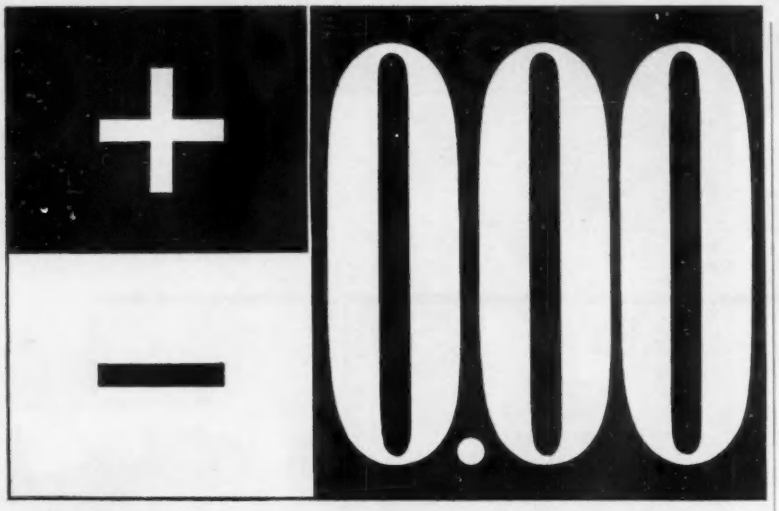
Subsidiary of ROCKWELL MANUFACTURING COMPANY

2240 DIVERSEY PARKWAY CHICAGO 47, ILLINOIS

In Canada: Republic Flow Meters Canada, Ltd.—Toronto

Manufacturers of electronic and pneumatic instrument and control systems for utility, process and industrial applications.

CIRCLE 135 ON READER-SERVICE CARD



• • • tolerance



Without quibble or qualification, a Meriam Manometer delivers perfect reproducible accuracy. This accuracy is absolute . . . no plus, no minus. Right on the button.
The same differential will always produce the same column height. Not close to the same height, but exactly the same height.
Other instruments struggle to come close. In a manometer, perfect reproducibility is inherent. It is routine . . . effortless.
How closely do you wish to "read-out" this perfect reproducibility? There are over one thousand different Meriam Manometer forms to answer this question. Sensitivity is selective, depending on the indicating fluid used. For example, one form of Meriam Inclined Manometer, using water, will provide graduations a full tenth of a linear inch apart, equal to 0.0005 psig.
Most important, Meriam has placed this perfect reproducible accuracy at the disposal of the plant operator as well as the lab technician. Rugged models serve along process lines outdoors as well as on central control panels.

NEW

. . . complete and informative guide to manometer theory and practice as well as manometer models for plant, field and laboratory use. Just ask for Bulletin G-14. The Meriam Instrument Company, 10920 Madison Avenue, Cleveland 2, Ohio.

FLOWS · PRESSURES · VACUUMS · LEVELS · DIFFERENTIALS

MERIAM MANOMETERS
...always accurate

CIRCLE 136 ON READER-SERVICE CARD

NEW PRODUCTS

gramming equipment. It is made of 0.005-in.-thick, slate-gray vulcanized fiber and falls between paper and polyester film in cost and wearing properties. It has a 6,000-psi tensile strength, high density, low porosity, excellent abrasion resistance, and is easily punched. Estimated maximum life is in the order of 1 million cycles.—National Vulcanized Fibre Co., Wilmington, Del.

Circle No. 263 on reply card



READ DC ON AC VTVM

Accessory shown makes it possible to use a standard ac-only vacuum tube voltmeter for microvolt dc readings. Called the Microdyne Type D-100 Voltmeter Inverter, it uses no tubes or transistors; instead it features a passive system built around quality choppers. Complete unit sells for $94. —Microdyne, Chicago, Ill.

Circle No. 264 on reply card

PLUS . . .

(265) **Fluid Controls Inc.**, Mentor, O., has announced production of a new **remotely-operated pilot-type relief valve** for maintaining constant relief pressure in hydraulic systems. . . . (266) **Barium ferrite,** a permanent magnet material with extremely high coercive force is now being offered by **D. M. Steward Mfg. Co.**, Chattanooga, Tenn. . . . (267) A new series of parallel-shaft, step-function **speed reducers,** by **Barry Controls, Inc.**, Groton, Mass., features in-line shafts for more convenient mounting in instrument drives. . . . (268) **Stitched wiring** is the name given by **Electronic Techniques, Inc.**, Los Angeles, Calif., to a new modular circuitry technique that affords greater reliability and conductivity.

Circle No. 265, 266, 267, or 268 on reply card

GET

more information about

1. Advertised products
2. New product items
3. Catalogs and bulletins

All advertisements, new products and literature items are numbered for your convenience.

One of these handy prepaid post cards will bring you detailed information

HOW TO USE THESE CARDS:

1. Find the key number on item of interest
2. Circle this number on one of the cards
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330 West 42nd Street
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Reader Service Department 2

CONTROL ENGINEERING
330 West 42nd Street
New York 36, N. Y.

INSTRUCTIONS

Use these reader service cards to get more information on advertised products, new product items or catalogs and bulletins appearing in Control Engineering's program control issue

IMPORTANT: Circle key numbers below and mail before December 1, 1958

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Name _____ Title _____

Company _____

Address _____ City _____ Zone _____ State _____

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Name _____ Title _____

Company _____

Address _____ City _____ Zone _____ State _____

1.

Circle number on card that coincides with key number listed at bottom or adjacent to item of interest.

2.

Fill in your name, title, company and address.

3.

Mail card immediately.

GET

more information about

1. Advertised products
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All advertisements, new products and literature items are numbered for your convenience.

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330 West 42nd Street
New York 36, N. Y.

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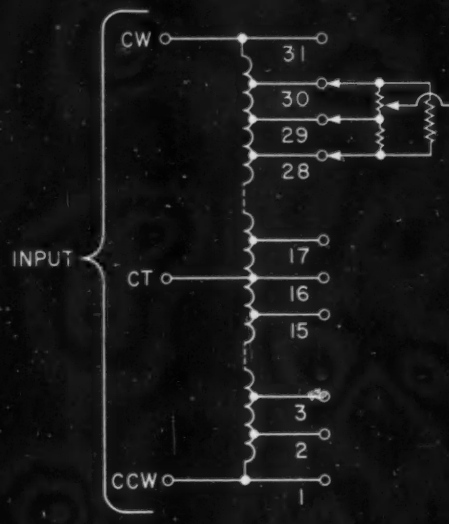
2.

Fill in your name, title, company and address.

3.

Mail card immediately.

with this unique principle...



In the Vernistat a-c potentiometer, a tapped autotransformer divides input voltage into 30 levels, which are interpolated by a one-turn potentiometer. By means of a unique switching method, 10 shaft turns connect potentiometer taps and autotransformer taps in synchronism with the wiper mechanism. Result: smoothly varied output over the entire voltage range.

and these combined features...

Low output impedance *(as low as 45 ohms)* with high input impedance *(as high as 200,000 ohms)* • High resolution *(up to 0.004%)* • Low phase shift *(as low as 0.2 minutes)* • High linearity *(as low as 0.01%)*

WHAT SYSTEM DESIGN PROBLEMS CAN VERNISTAT* HELP YOU SOLVE?

With a fundamentally new concept in relating shaft rotation to voltage, the Vernistat a-c potentiometer brings to electronic designers a wholly new combination of features not previously available in a standard potentiometer. As a result, new design improvements and economies are made possible in servo systems, analog computers, many other similar applications—perhaps including yours, too – with these advantages:

Reduces system complexity and cost. With this one compact device, you can eliminate isolation amplifiers, shielded cables, summing resistors with resultant signal loss, and separate transformers with accurate center taps. Quadrature rejectors, as well as other phase-compensation schemes, are generally unnecessary.

Increases system reliability and accuracy. With fewer system elements, system reliability goes up. High linearity, an inherent Vernistat feature, is maintained over its entire life. Low phase shift, another plus, helps attain accuracy.

Permits greater design freedom. The Vernistat is easily modified to provide similar basic features in nonlinear functions with excellent conformity. Unlike helical-type units, it can be continuously rotated because of its planetary principle. A wide selection of models is available which meet military specifications.

• • •

Besides precision a-c potentiometers, Vernistat products include function generators (adjustable nonlinear potentiometers) and variable ratio transformers. Design principles, applications, technical data, prices, and specifications are all included in a new 16-page brochure. Write now for your copy.

vernistat division

PERKIN-ELMER CORPORATION

766 Main Avenue Norwalk, Conn.

*vernistat® *a new design concept that unites in one compact device the best of both the precision potentiometer and the autotransformer.*

NEWEST ADDITION to the Vernistat line is a miniaturized a-c potentiometer (synchro size 11). See brochure for specifications.

CIRCLE 137 ON READER-SERVICE CARD

NEW!

GREATER...

• OUTPUT

• STABILITY

• ACCURACY



• Multi-column

• Smaller size

• Hermetically sealed

Cox and Stevens

LOAD CELLS

For greater accuracy and stability in all types of weight and force measurement, specify new Cox and Stevens hermetically sealed load cells. Sixteen strain gages in multi-column design provide up to 250% greater output, improved stability and better uniformity between cells. Capacities range from 500 to 200,000 lbs. All cells with 30 feet of special moisture- and chemical-resistant cable in stainless steel jacket.

Cox and Stevens' fifteen years experience in designing and manufacturing load cells, plus dead weight testing facilities which make possible calibration to higher accuracies, assure maximum reliability. Write for technical bulletins.

TYPICAL SPECIFICATIONS

1. Recommended Input:.....20 volts
2. Change in Output, No Load to Full Load:.....1.750 ± .1% millivolts/volt input
3. No Load Output:.....± .25% of full load output
4. Output Linearity:.....0 to + .20% of full load output
5. Temperature Effect on Cell Output (15 to 115°F):.....± .0008%/°F of output at applied load
6. Temperature Effect on No Load Output (15 to 115°F):.....± .0013%/°F of full load output
7. Input Impedance at 75°F:.....450 ± 1 ohms
8. Allowable Load:.....225% of rated capacity
9. Deflection Under Rated Load:.....Less than 0.003"

OTHER REVERE PRODUCTS

• INSTRUMENTS and SYSTEMS For controlling and indicating liquid flow and level, and for volumetric or gravimetric metering.

• HIGH TEMPERATURE HOOK-UP and THERMOCOUPLE WIRE and CABLE

• THERMOCOUPLE AND ELECTRICAL HARNESSES AND LEADS

• ELECTRO-MAGNETIC SWITCHES and RELAYS

53D

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REVERE CORPORATION OF AMERICA

Wallingford, Connecticut

A SUBSIDIARY OF NEPTUNE METER COMPANY

neptune

CIRCLE 138 ON READER-SERVICE CARD

BULLETINS AND CATALOGS

(300) POT TERMINOLOGY. Bournes Laboratories, Inc. Bulletin IDEF/B/8, 2 pp. Provides up-to-date definitions of terms used to describe wirewound potentiometer instruments, based on the National Aircraft Standards Committee Specification NAS 710.

(301) INDUSTRIAL SERVOVALVE. Vickers, Inc. Bulletin 58-74, 4 pp. Covers general specifications, torque-motor characteristics, and operation of the Series E-11089-4 electrohydraulic servovalve for industrial applications. Curves illustrate frequency response and flow vs. differential current.

(302) THERMOWELLS. Trinity Equipment Corp. Data Sheet 4582, 2 pp. Contains detailed information on a variety of weld-in type thermowells for application in the power and process industries. Diagrams show typical installations and types of connections.

(303) ADJUSTABLE-SPEED DRIVES. Cutler-Hammer, Inc. Publication EN-64, 14 pp. Describes Ultraflex E, a line of adjustable-speed dc packaged drives using electronic tubes for power conversion Separate sections cover the controls, power conversion units, components, and protective systems.

(304) VALVES. The Mercoid Corp. Catalog V-58, 24 pp. Loaded with illustrations and specification lists on magnetic and motorized valves for use with air, water, gas, steam, oil, and refrigerants. Other features include solenoid coil rating tables, flow charts, and dimensional data.

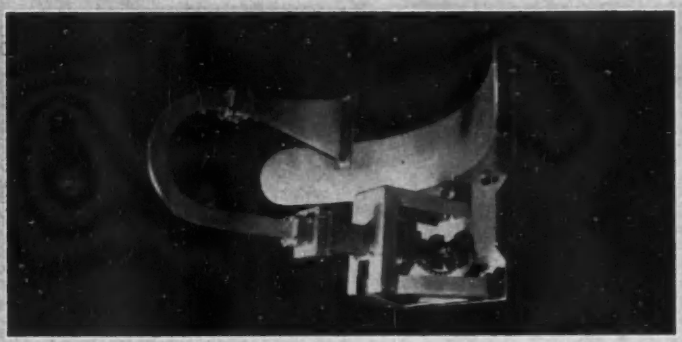
(305) THERMISTOR INFO. Victory Engineering Corp. Five 4-page folders. A fascinating and educational story of the growth and variety of present-day thermistor applications. Each folder contains illustrations, circuit diagrams, tables, and charts.

(306) SELECTOR SWITCH. G. H. Leland, Inc. Bulletin 158-HV, 2 pp. Gives performance data and environmental conditions of a new hermetically-sealed rotary selector switch. Sheet also describes test conditions and provides dimensional drawings, a header pin diagram, and wiring charts.

(307) SOLENOID VALVES. J. D. Gould Co. Bulletin 500 C, 4 pp. Includes pictures and descriptions of 13 basic types of solenoid-operated valves in sizes from ⅛ to 4 in. Sectional drawings illustrate open and closed positions as well as the operation of a typical valve type.

(308) SEMICONDUCTOR APPLICATION. Hoffman Electronics Corp. Application Notes Nos. 5 & 6, 8 pp. This combined edition of two application notes deals with the design of pulsed magnetic amplifiers and their use in logic circuit design. Schematics and waveshape plots illustrate the text.

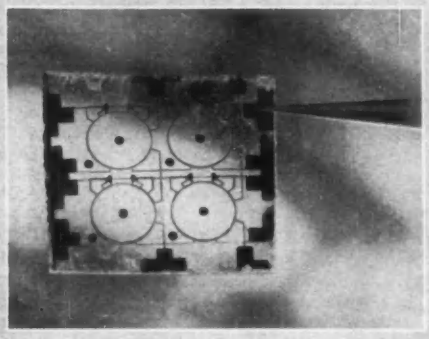
(309) VOLTAGE REGULATORS. Electric Regulator Corp. Bulletin 1.050, 2 pp. Sheet contains data on the operation and performance of the Series 1.050 precision filament-voltage regulators. Circuit diagram shows components of a typical unit.



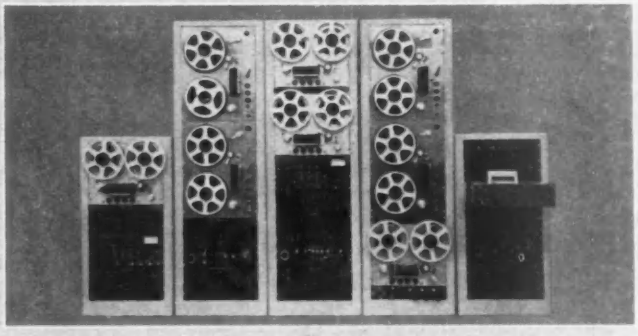
Horn fed parabolic reflector antenna for airborne applications.



Charged aluminum particle suspended and controlled in a vacuum chamber by an oscillating electric field.



The Persistor gives promise of cryogenic computer memories with a capacity of 1,000,000 bits per cubic foot and access times of 1/30 microsecond.



Ground based data handling equipment for processing analog and digital reconnaissance information.



Data conversion system for digitizing and processing telemetered missile test data.



Electron micrograph of impact produced on aluminum coated glass by a 1 micron diameter particle traveling at 7,000 feet per second.

Pictorial **PROGRESS REPORT**

The photographs above illustrate some of the recent research, development, and manufacturing activities at Ramo-Wooldridge. Work is in progress on a wide variety of projects, and positions are available for scientists and engineers in the following fields:

- Digital Computers and Control Systems
- Communications and Navigation Systems
- Guided Missile Research and Development
- Infrared Systems
- Electronic Countermeasures
- Electronic Instrumentation and Test Equipment
- Basic Electronic and Aeronautical Research

The Ramo-Wooldridge Corporation

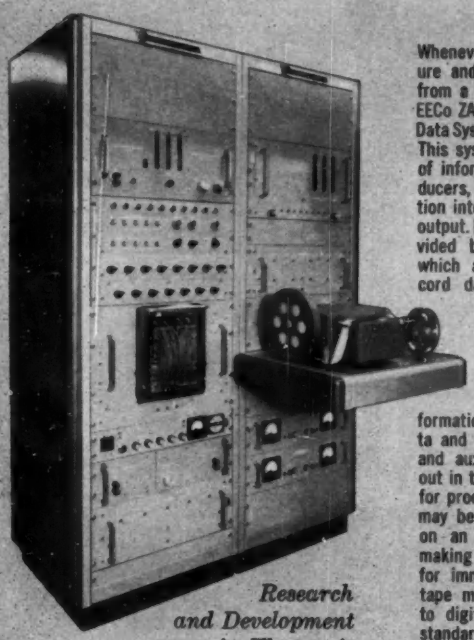
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ANALOG-PUNCHED TAPE DATA SYSTEM



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Whenever there is a need to measure and record quasi-static data from a variety of d-c inputs, the EECo ZA-750 Analog-Punched Tape Data System should be considered. This system accepts 20 channels of information from analog transducers, and converts the information into an 8-level punched tape output. Maximum flexibility is provided by the plug patch-board, which allows the system to record data in various sampling sequences. Interchangeable patch-boards permit specific data formats or problems to be set up and retained for use. Additional information such as time-of-day data and preselected identification and auxiliary data can be read out in the format most convenient for processing. The punched tape may be used for digital readout on an electric typewriter—thus making the test data available for immediate reporting—or the tape may be used as the input to digital computers which use standard 8-level coding. Write for detailed information on model ZA-750 System, Section CE, Sales Dept.

EECo's 11 years of experience in many fields of research and development provides the knowledge, facilities, and ability to quickly and efficiently design equipment and systems to solve instrumentation problems. Our engineers will be happy to discuss specific applications.

Electronic Engineering Company

of California

1601 E. CHESTNUT AVE., SANTA ANA, CALIF. · Kimberly 7-5501...TWX: Santa Ana, Cal 9063

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Bulletins & Catalogs

(310) CONTINUOUS WEIGHING, Omega Machine Co. Bulletin 36-P1, 2 pp. Lists the advantages of a new belt stream weigher for continuous weighing of dry material. Operation and available accessories are described and dimensional drawings included.

(311) GAS SAMPLING SYSTEM. Bailey Meter Co. Product Specification E65-6, 4 pp. Describes a complete gas sampling system for analysis work involving hot dirty gases at temperatures up to 3,200 deg F. Drawings illustrate a variety of sampling tubes and typical piping.

(312) RECORDING AND CONTROL. Midwestern Instruments. Brochure, 20 pp. Ruggedness and accuracy are said to be standard in this company's instrument line. Photos and brief descriptions cover: oscillographs, bridge balances, torque motors, and hydraulic servovalves.

(313) ON DATA TRANSLATION. Telemeter Magnetics, Inc. Bulletin, 4 pp. Typical functions and applications of TMI data translators are listed here to show how this equipment can save costly data processing time by improving the compatibility of different data handling systems.

(314) ROTARY STEPPING SWITCH. North Electric Co. Bulletin 204-51, 2 pp. Exploded view and dimension drawings illustrate the construction of a new rotary stepping switch for programming, sequencing, and testing applications. Also includes a graph showing the response curve for a typical 24-volt switch.

(315) CONTROLLED SPEED SYSTEMS. U. S. Electrical Motors, Inc. Bulletin F-1952. Provides descriptive and application information on the company's load-control systems for use on grinding mills and similar industrial equipment.

(316) DATA HANDLING. Datamatic Div. of Minneapolis-Honeywell Regulator Co. Brochure, 16 pp. Fully describes the DATAmatic-1000 electronic data processing system. Two-page photo and schematic illustrate the following units: read-write, control, arithmetic, high-speed memory, input-output buffer, central console, and power distribution.

(317) UNBOUND STRAIN GAGE. Statham Instruments, Inc. Bulletin No. 1.02, 2 pp. Compares the operating principles of two types of unbonded strain gages: the conventional and Statham's Zero-Length type. One figure shows how the latter type can be used to form a complete bridge circuit with all four elements active.

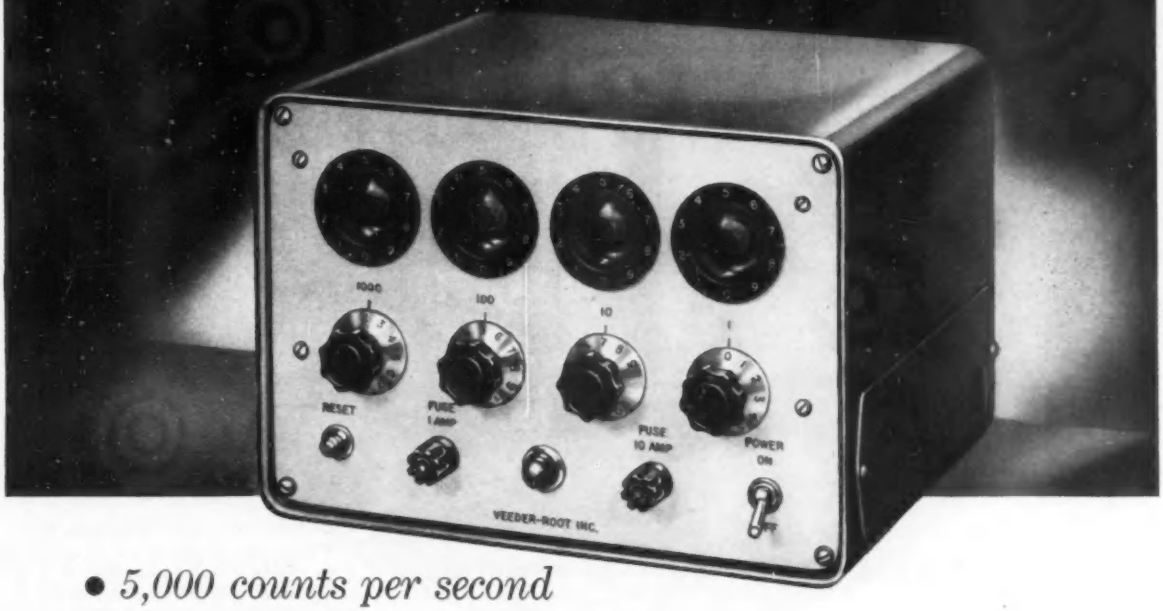
(318) PROPORTIONAL CONTROL. Electronic Processes of California. Bulletin, 2 pp. High accuracy at low cost, single-knob simplicity, and independent control and indicating functions are listed as typical features of a new indicating proportional temperature controller.

(319) SERVO COMPONENTS. Servomechanisms, Inc. Bulletin, 12 pp. A general product survey, this bulletin provides brief descriptions of various subsystem components without going into detailed specifications. Starts with a few short paragraphs on the company's history, general facilities, and design philosophy.

(320) COIL STOCK CALCULATOR.

NEW

TRANSISTORIZED PREDETERMINING COUNTERS



- *5,000 counts per second*
- *Instantaneous recycling*
- *Increased reliability*
- *Industrial design*



A versatile group of transistorized production counters designed for industrial applications. Any number of decades can be furnished depending upon your requirements.

Can be operated by non-technical help merely by setting the selector knobs to the pre-set quantity within the range of the instrument. These counters are ideal for batch control, sequential predetermining, or accurate length control in such applications as packaging, coil winding, slitting, stacking and material handling.

The use of transistors means that heat — the enemy of reliability — has been eliminated. This reduces warm-up time and increases dependability. Printed circuits and simplified wiring further insure long trouble-free operations.

Standard counters are completely enclosed in attractive industrial cases, but can also be supplied without enclosures for panel mounting. A photo head to actuate these counters can be furnished in many configurations. Batch totalizers with push-button reset and special modifications of basic components can be furnished on request.

This is your complete package for predetermining counting at high speeds. Send for your copy of the new specification bulletin outlining the complete range of the series 1604 counter line today.

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In the college classroom, or "on the job" in industry, the Heathkit Analog Computer solves physical or mechanical problems by electronic simulation of conditions. Full kit $945.00



This advanced "slide-rule" is a highly accurate device that permits engineering or research personnel to simulate equations or physical problems electronically, and save many hours of involved calculation.

Ideal for industry, research, or instructional demonstrations. Incorporates such features as:

- **30 coefficient potentiometers, each capable of being set with extreme accuracy.**
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Now for the first time, the cost of this highly accurate, time and work-saving computer need not rule out its use—You assemble it yourself and save hundreds of dollars.

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Bulletins & Catalogs

F. J. Littell Machine Co. Handy calculator permits a user to readily determine the amount of material needed for coils of any size. Inside and outside diameters, width, and thickness of the stock are all that the user needs to operate the calculator.

(321) FOR LIQUID LEVEL. Electronics Corp. of America. Bulletin PF 571, 16 pp. Both electronic and electromagnetic types of liquid level controls are described. Includes 12 illustrated applications and a concise chart for selecting the proper control system for a wide variety of liquids.

(322) TAPE INSTRUMENTATION. Ampex Corp. 16-page bulletin plus 4-page specification sheet. Completely describe the application, operation, and special features of the FR-100A Modular Magnetic Tape Recorder/Reproducer. Spec sheet includes data on the tape transport, servo tape speed control system, recording heads, and the direct, fm-carrier, PDM, and NRZ-digital systems.

(323) RUPTURE DISCS. The Carbone Corp. Two-page bulletin. Describes a new line of rupture discs for use wherever the problems of over-pressure and corrosion are combined. Standard specifications and a dimension table are provided.

(324) SERVO ACTUATOR. Lear, Inc. Product Data 111-8, 2 pp. Photo and typical installation drawing illustrate this description of the Series 3050 servo actuator, a unit designed for driving control surfaces in hypersonic flight.

(325) "FLUID POWER NEWS". The Oilgear Co. News 7, 4 pp. Data taken from the company's application-engineering files describes solutions to problems in modern marine stearing gear, a servo-controlled mobile drilling barge, and ships' freight elevators.

(326) PNEUMATIC CONTROL. Fischer & Porter Co. Specification 51-1212W-1, 4 pp. Covers each component of a new one-pen miniature recording control station developed to handle a single 3-15-psi pneumatic signal. Drawing shows typical arrangements for use with field-mounted or plug-in controllers.

(327) COMPUTER COMPATIBILITY. Electronic Engineering Co. 4-page brochure. Deals with the operation, application, and economical design of the Model ZA-100 Computer Language Translator for integrating computer and data-processing systems having normally incompatible formats.

(328) SWITCH LINE. Grayhill, Inc. Catalog No. G-300, 24 pp. Provides detailed specifications on a complete line of miniature pushbutton switches, rotary switches, binding posts, test clips, and miscellaneous components. Data includes electrical ratings, life load tests, materials used, applications, and construction details.

(329) SPEED CONTROL. U. S. Electrical Motors Inc. 8-page brochure. Shows how precise speeds may be set up and maintained through use of the Varitrol speed drive and pneumatic control system. Includes drawings of typical applications in full color.

NEW AiResearch steering control system



Combines Acceleration Switching Valves And Hydraulic "Printed Circuit"

More reliable and responsive... this lightweight electro-hydraulic steering control system converts low-level electronic signals from the main guidance system into hydraulic energy which actuates the mechanisms steering the missile.

Packaged as an integrated unit, the three servo valves and six control actuators are mounted on a common manifold and powered by fluid or hot gases. The simplified "printed circuit" system of integral passageways within the manifold eliminates all external plumbing and leakage.

The acceleration switching servo valves provide positive control of spool velocity, thereby achieving greater resolution, reliability and response even at extreme temperatures.

Easily installed and removed as a complete, interchangeable unit, acceptance testing of this compact system can be accomplished prior to missile installation. Suggested applications are: missile surface controls, jetavator controls, and vector and nozzle steering controls. Your inquiries are invited.

Specifications

Actuator load (range)	*90 to 150 in. lbs.*
Electrical input (nominal)	*28 volts DC—10 Milliamperes*
Pressure range	*500 to 3000 psi*
Rated flow	*½ to 2 gpm*
Mounting	*Manifold*
External leakage	*None*
Proof Pressure	*4500 psi*
Burst Pressure	*7500 psi*
Temperature operating range	
Fluid	*-65°F to 450°F*
Ambient	*-65°F to 750°F*
System filtration	*10 microns*

ENGINEERING REPRESENTATIVES: AIRSUPPLY AND AERO ENGINEERING, OFFICES IN MAJOR CITIES

THE GARRETT CORPORATION

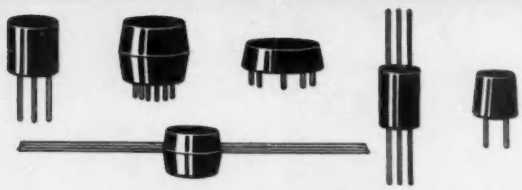
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Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

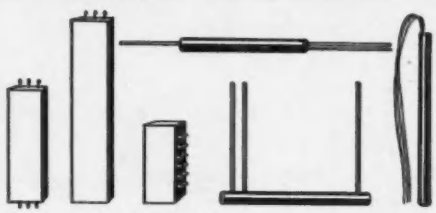
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TECHNITROL
ENGINEERING COMPANY



PULSE TRANSFORMERS

Whatever your requirements may be for miniature pulse transformers, Technitrol has a design that will meet your circuit specifications. Commercial or Mil-T-27A low-power transformers with pulse widths ranging from 0.05 to 20 μsec. are available as standard stock components. *Send for Catalog 166*



DELAY LINES

Technitrol manufactures and maintains a complete stock of distributed parameter delay lines in standard package form for plug-in or pigtail mounting. Specially-designed delay lines to meet specific performance characteristics are available on order. *Send for Bulletin 174.*

TEST INSTRUMENTS

Diode Tester: for rapid, accurate checking of semiconductor diodes using dynamic curve. *Send for Bulletin 1001*
Cathode Ray Indicator: a visual indicating device for observing the output of diode testers and transistor curve tracers. *Send for Bulletin 1002*
Variable Pulser: converts any type of signal source up to 5 mc. into standardized pulses of controlled amplitude and duration. *Bulletin 1010*
Variable Frequency Oscillator: supplies a source of frequencies from 100 cps. to 5.6 mc. in 7 bands with continuous tuning over each band. *Send for Bulletin 1011*

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W. B. Pray Sales
44 Washington St.
Wellesley 81

Tuckahoe:
Land-C-Air Sales Co.
140 Marbledale Rd.

COLORADO
Hytronics Meas., Inc.
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MINNESOTA
Edward Hoffman Co.
216 Liberty Bank Bldg.
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CIRCLE 143 ON READER-SERVICE CARD

Bulletins & Catalogs

(330) TORQUE-RPM CHART. John Oster Mfg. Co. A new easy-to-read chart tabulates oz-in. torque vs. rpm at stated horsepower. Information ranges from 1/2,000 hp to ¼ hp and from 1 to 14,000 rpm.

(331) SERVO COMPONENTS. Precision Mechanisms Corp. Bulletin No. 102-58, 6 pp. Deals with the versatility of a new line of predesigned mechanisms and components for use in the servo and instrument fields. Material also covers enclosures, technical data, and special requirements.

(332) TUBE CLAMPS. Birtcher Corp. Catalog 5-KK, 14 pp. Offers detailed information on 17 different types of cooling and retaining clamps, of silver and beryllium copper alloy, for miniature and subminiature tubes and components, including those with 90-deg sockets for printed circuitry.

(333) LINEAR ACTUATOR. Lear, Inc. Product Data 111-9, 2 pp. A list of specifications and a typical set of performance curves tell the reader quite a bit about the Series 3064 linear servo actuator, a unit originally designed for yaw damping in a high-performance aircraft.

(334) PRODUCTS & FACILITIES. Thompson Products, Inc. Catalog, 28 pp. First covers a little of the company's history and present facilities, then goes into a detailed catalog of products ranging from electronic control subsystems to compact switching assemblies.

(335) PRECISION POTS. Electromath Corp. Brochure with eight data sheets. Describes the principal features and detailed electrical and mechanical specifications of a complete line of single- and multi-turn potentiometers. Dual units and high-temperature units are also included.

(336) AIR & HYDRAULIC. Pathon Mfg. Co. Bulletin 25, 36 pp. Provides information on the dimensions, construction, and materials for three series of air and low-pressure hydraulic cylinders. Useful nomograph gives maximum push stroke for any given cylinder.

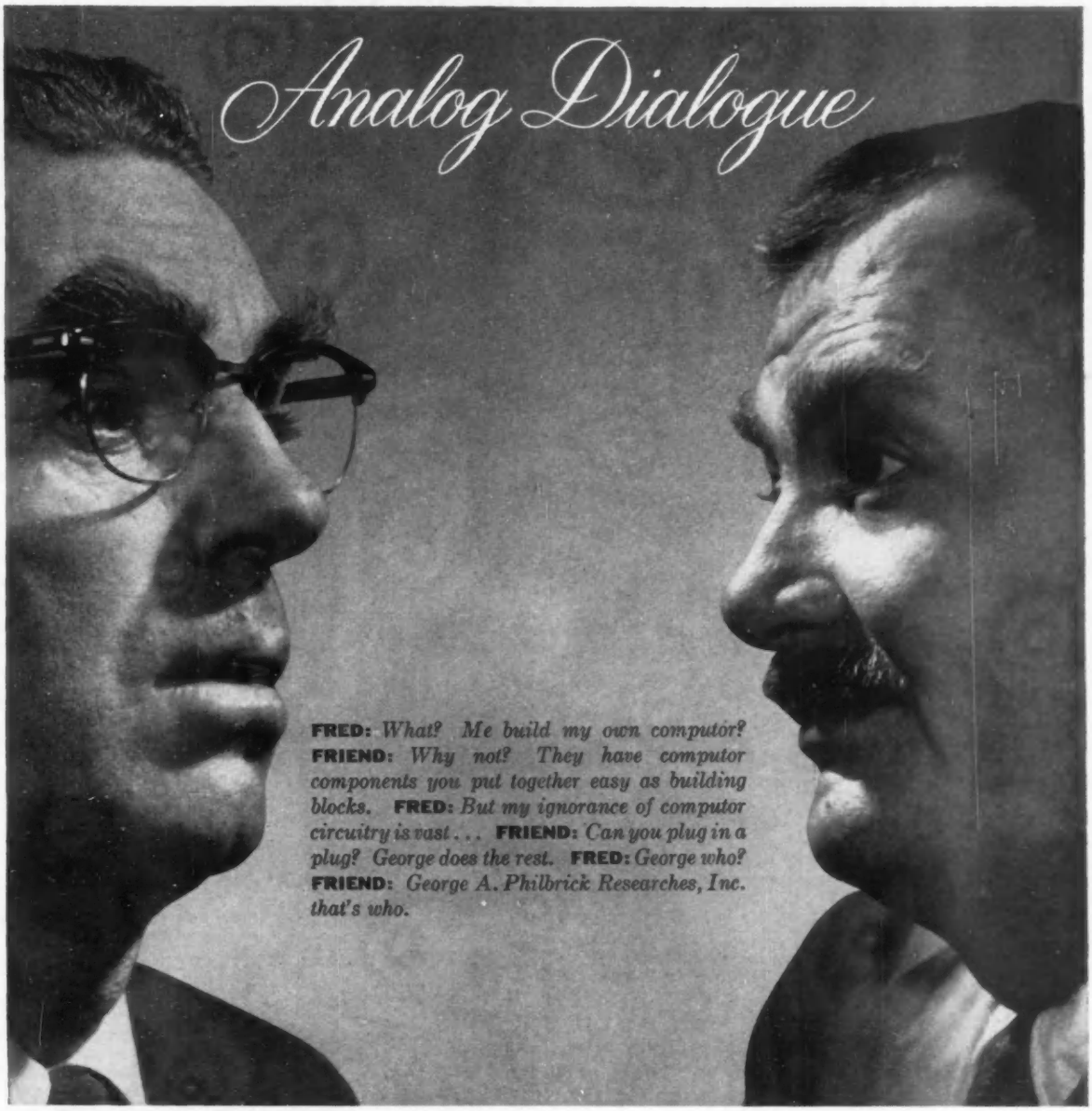
(337) TINY DC MOTORS. Globe Industries, Inc. Collection of 10 2-page bulletins. Material describes four different types of miniature dc motors, associated spur and planetary gear boxes, governors, and radio noise filters. Motor types include both permanent magnet and wound field.

(338) SHORTER CONNECTORS. Cannon Electric Co. Catalog MS-E-3, 16 pp. Covers all Type E Cannon plugs conforming to the provisions of the military specification MIL-C-5015. Photos, drawings, tables of dimensions, and two exploded views are included.

(339) TAPE & FILM ERASER. Radio Corp. of America. Bulletin 15-1, 4 pp. Includes information on the features, construction, and operation of a device for automatically erasing magnetic signals from new and recorded tape and film.

(340) INFORMATION SYSTEMS. Bailey Meter Co. Bulletin E72-1, 8 pp. Shows how field measurements of process variables made locally and/or remotely are received and displayed in digital form.

Analog Dialogue



FRED: *What? Me build my own computor?* **FRIEND:** *Why not? They have computor components you put together easy as building blocks.* **FRED:** *But my ignorance of computor circuitry is vast . . .* **FRIEND:** *Can you plug in a plug? George does the rest.* **FRED:** *George who?* **FRIEND:** *George A. Philbrick Researches, Inc. that's who.*

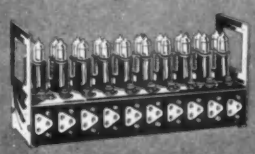
MORAL: *For anything in analog, see Philbrick. GAP/R has the world's most complete line of electronic computors and components. Write for freely given opinions on individual applications.*

GEORGE A. **PHILBRICK** RESEARCHES, INC.

285H COLUMBUS AVENUE, BOSTON 16, MASSACHUSETTS

. . . . . The analog way is the model way . . . . . .

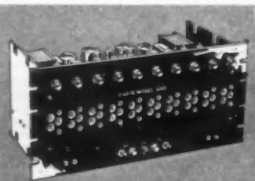
Choose from compact, convenient, economical components like these:



HK Operational Manifold



UPA-2 Utility Packaged Amplifier



HKR Powered Operational Manifold



K5-U Universal Linear Operator

COMMAND SIGNAL GENERATOR — COMMAND SIGNAL RECEIVER — SYNCHRO POSITIONER — AUTO PILOT CONTROL



STEPPER
SYNCHRO POSITIONER

Accuracy: Within 6 min. of arc when driven by either motor.

Incremental shaft rotation: 2 degrees.

This is one of the many applications for the Stepper Motor — a device for translating electrical pulses into accurate, bi-directional, incremental shaft displacements.

The Synchro Positioner uses two Stepping Motors, an Autosyn differential, and a built-in pulse generator. One motor positions the Autosyn Shaft in coarse increments in either direction, while the other motor, using a different gear ratio, positions the same shaft in vernier increments in either direction. As the reset command signal is of steady-state type, the built-in pulse generator permits use of the driving motors for the reset function.

STEPPER MOTORS CORPORATION
Subsidiary of California Eastern Aviation, Inc.
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CIRCLE 145 ON READER-SERVICE CARD

WHAT'S NEW

(Continued from page 58)

such as the chemicals, petroleum processing, steel, pulp and paper, etc., the benefits of analog computation appear as intangibles due to lack of historical data. Our trade-in program will afford opportunities to people in these fields to try out analog computation at modest investment or low rental rates.

• **Good for a start**—"The reconditioned trade-ins will not provide the latest in programming techniques but will, as they did for their initial user, perform simulations and analyses which save time and money and provide design information not otherwise obtainable—thus clearly providing tangible justification for further application of analog computers."

If anyone gets a break, then, Mid-Century wants to be sure it is the new user, for he is the one who must be sold on the benefits of analog computing. In his case in particular, Mid-Century is not out to make a profit. If, said Stern, the seller of a used machine is satisfied with, say, $10,000, when its original cost was much more, $10,000 will be the amount on which Mid-Century will base the new lease.

Now It's: Bryant Computer Products, Bendix Industrial Controls

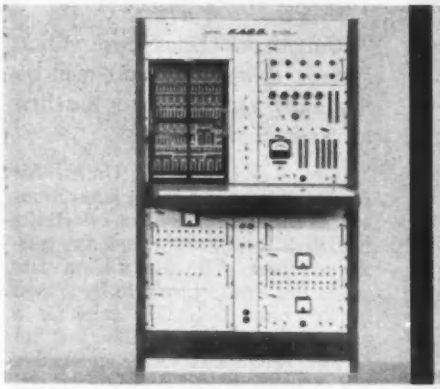
Two companies have changed the names of important groups to conform more strictly to intent and product. The groups are: the Bryant Gage & Spindle Div., renamed the Bryant Computer Products Div. by Bryant Chucking Grinder Co., and the Controls Section, renamed Industrial Controls Section by the parent Bendix Aviation Corp. Bryant's section has, in addition, been reorganized to concentrate on magnetic storage devices for electronic computers. Personnel and manufacturing facilities have been increased, too.

Hagan Chemical & Controls Purchases Kybernetes Corp.

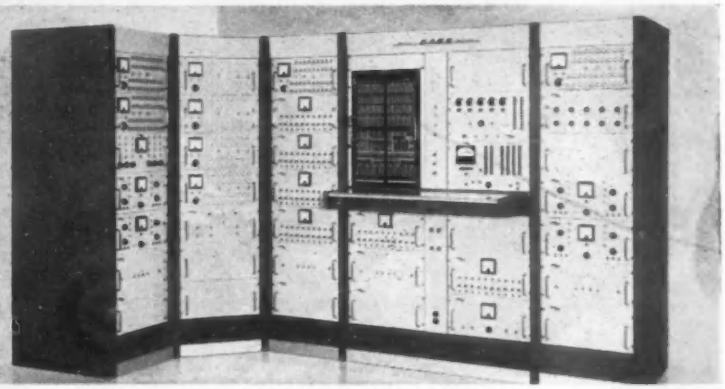
"By acquiring a proven, ready-made entry into the data-handling field, we have stepped up our normal development by three to five years," said Hagan Chemical & Controls President William W. Hopwood, in announcing his company has purchased The Kybernetes Corp. Plans are to make Kybernetes part of Hagan's Instruments & Controls Div. at Orrville, Ohio.

EASE® ANALOG COMPUTERS

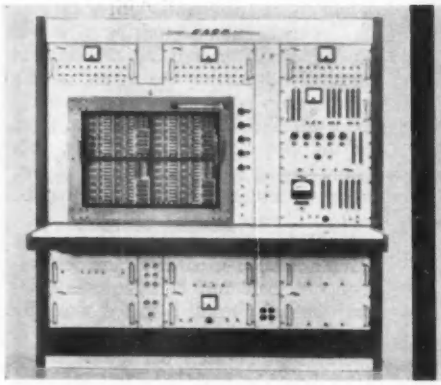
grow step-by-step with your needs.



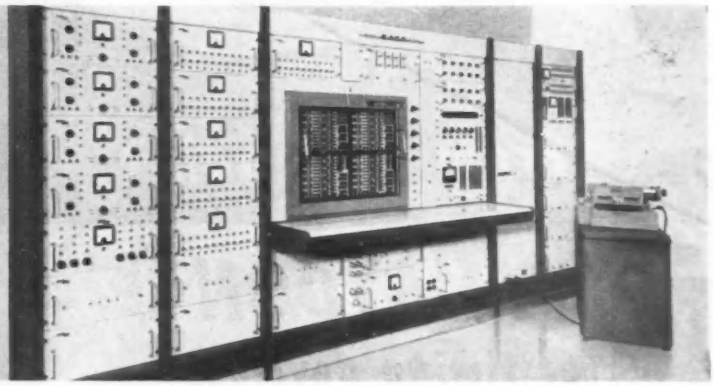
An Initial Installation. For the solution of comparatively simple linear differential equations you might use this 2120-terminal patchbay and control unit serving 20 amplifiers and 30 servo-set pots.



After Several Expansions. The original installation at left has been progressively expanded without modification to handle complex non-linear equations involving empirical functions. Now includes 60 amplifiers, 2 servo-multipliers, 14 electronic multipliers, 8 function generators and 100 pots. Other non-linear components can be accommodated. Capacity may be doubled by adding a second patchbay.



Another Initial Installation. The 3600-terminal patchbay offers a somewhat more ambitious starting point. Here the control unit serves 30 amplifiers, 2 servo-set function generators and 100 servo-set pots.



After Expansion to One-Half Capacity. Without disturbing the initial installation, the computer can be expanded to include 100 amplifiers, 20 function generators, 24 multipliers, 12 servo multiplier-resolvers, 200 pots and 8 relay amplifiers. Computer shown includes a digital voltmeter, digital clock and the "DO/IT" system for entering, programming and recovering data by typewriter.

An EASE installation large enough to handle the bulk of current computational work can be expanded at a later date without sacrificing any part of the original investment. Small "core" installations, possessing the unequaled accuracy of all 1100 Series computers, place no limitation on the accuracy, versatility or reliability of fully-developed facilities. Expansion can take place in small increments and in any direction best suited to the needs of the user. Components already installed can be shifted easily from one rack to another as convenience dictates.

The small computer provides design engineers with a perfect opportunity to learn efficient analog simulating techniques. Experience gained solving simpler problems enables an engineer to select the most fruitful approach to more difficult problems and helps him make a wise choice of additional equipment as the need arises.

Write us for literature giving further details on available equipment.

161

Computational service is available on a rental basis at our well-staffed computer facility. For details write Kenneth A. Tuttle, Director Beckman/Berkeley Computation Center, 305 Parkman Ave., Los Angeles 26, California.

Beckman® / ***EASE COMPUTERS***

Mfd. by Berkeley Division, Beckman Instruments, Inc. Richmond 3, California



...it's HAYDON*

for timing devices

If you're looking for a complete product line *that includes Timing Devices for every application requirement and, in addition, features the highest quality and most advanced design at the lowest possible cost, HAYDON has it! And all Haydon timing devices incorporate the famous Haydon hysteresis and/or inductor timing motors available for 50, 60, and 400 cycle and DC power supplies.*

If you're looking for a complete service *to meet all your timing needs, HAYDON offers fully integrated engineering and manufacturing facilities ready to take your timing projects right through from design and development to finished product!*

And if you're looking for a complete Field Engineering Service *to make all these facilities conveniently available, you'll find there's a HAYDON Timing Specialist in your area, a man fully qualified by training and experience to help fill your Timing Device needs. Why not phone him today and make an appointment to discuss your requirements?*

*Trademark Reg. U.S. Patent Office

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HEADQUARTERS FOR TIMING

HAYDON

Division of General Time Corporation
2333 East Elm St., Torrington, Conn.

CIRCLE 147 ON READER-SERVICE CARD

WHAT'S NEW

Teleregister's Biggest

United Air Lines' reservation system, coming in 1960, will be the most versatile and the first to use a computer.

By the end of 1960, United Air Lines will have installed a reservations system that does just about everything but tuck a pillow behind the passenger's back. The $16 million data processing contract, said to be second in size only to SAGE, calls for a gargantuan effort on the part of builder Teleregister Corp. and makes the systems it has already designed (among them: CtE, April '57, p. 34, Dec. '56, p. 154) look like practice.

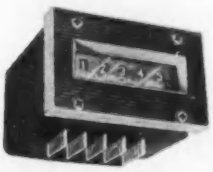
Three digital computers—Teleregister's own brand, called Telefiles, solid-state units with capacities between that of an IBM 650 and an IBM 705—will check space availability, sell and cancel space, handle waiting lists, and do practically everything else that is normally done by the agent in his relationship with a customer. In addition, the Telefiles will handle a flock of so-called "off-line" functions, too, those having to do with sales analyses, financial forecasts, passenger demands, airline income, etc.

• **Needed: a computer**—Computers have not been used in airline reservation systems before. The systems Teleregister has already installed work by means of a wired program, which is pretty sophisticated itself, but is far from being as flexible as the one contemplated for United. But then, these earlier systems do not deal with off-line data, nor do they provide the fast service that United's will. Examples: average time for making a reservation: 1½ sec; time for making 80 percent of all reservations: less than 1 sec.

Said Langdon Sully, assistant to the president of Teleregister: In the American Airlines system, one of the first his company installed, reservation time ran to almost 15 sec. This is not long ordinarily, but it may seem that way to the traveler who is caught up in some personal emergency.

Still another first for the United system will be its use of first-class telephone lines to transmit the on-line data. Transmission speed will be in excess of 1,300 words per min, which is 15 times faster than anything possible in reservation systems today. Every second of this 1,300-word minute, 15 to 16 transactions will be able to take place.

• **Gets most out of print-out**—There



COMPARE FEATURES AND YOU WILL SPECIFY NEURON!

Neuron High-Speed Electromechanical Counter, now manufactured by the Data Instruments Division of Telecomputing Corporation, is the same highly reliable Neuron counter which has enjoyed wide acceptance in a great variety of totalizing applications. ▪ Prompt Delivery – assured by Telecomputing's resources and facilities. ▪ High Speed – counting rate to 40 per second. ▪ Precision – cannot double index. Full count registered on leading edge of input pulse. ▪ Add and Subtract – accepts random add and subtract pulses. ▪ Instant Reset – mechanical or electrical. ▪ Environmental Capabilities – balanced moving elements provide exceptional resistance to vibration and shock. ▪ Switch and visual readout. ▪ Designed for panel mounting. ▪ Specify Neuron for the solution of tabulating problems that ordinary counters cannot solve. For complete information, write, wire, phone, DATA INSTRUMENTS DIV. ▪ TELECOMPUTING CORP., 12838 Saticoy St., N. Hollywood, Cal.

[redacted] + the only electromechanical totalizer with switch-readout capable of adding and subtracting

CIRCLE 148 ON READER-SERVICE CARD

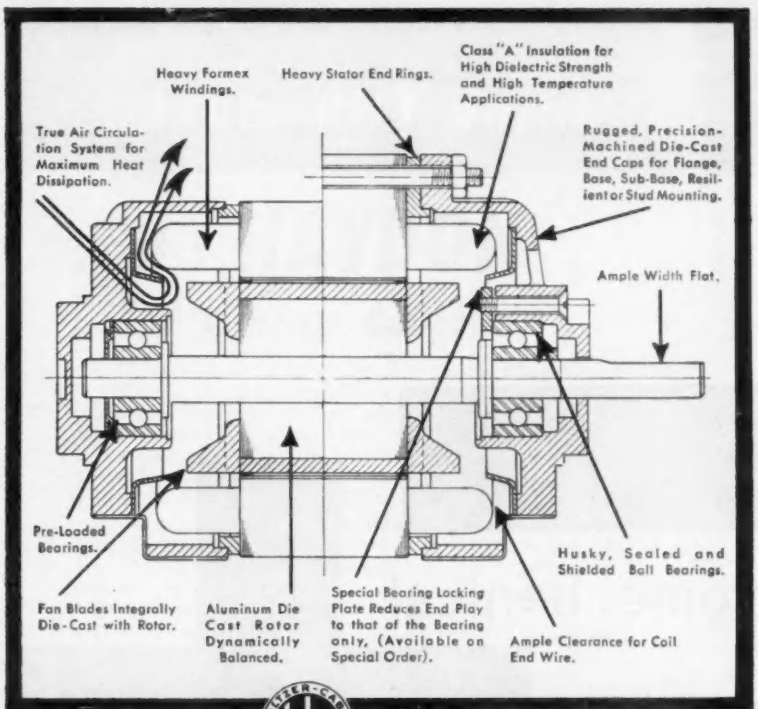
New Designs in Motors from HOLTZER-CABOT



Many Standard Mountings Available

TYPE R-29 MOTOR
2⅞" Diameter

This motor is an ideal power source for recording instruments, timers, medical instruments, office equipment, blowers, tape recorders, communications equipment, etc. It is available in both 2-pole and 4-pole design, each in three stacking lengths. Type R-29 is a permanent split capacitor type available as an induction or synchronous motor. H.P. of various models ranges from 1/75 to 1/30. Construction features are indicated below.



For more information, write, or use Readers' Service Card.

Sales — Service Representatives in Principal Cities throughout the World

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston, Massachusetts

Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems

CIRCLE 149 ON READER-SERVICE CARD

will be two types of print-out, one visible, the other not, but both having to do with space sales. The visible print-out, coming through a keyboard device at the agent's set, will contain all the details of an intended flight (time of departure, date, etc.). The agent will simply fill in the passenger's name and the telephone number at which he can be reached, then file the information in local records.

The other output is more unique. It is a record of the very same information, but it is on magnetic tape. Needless to say, this tape is the source of much available "off-line" data.

Three magnetic drums, each with a capacity of 1 million decimal digits, and nine magnetic tape units will provide the system's main memory. Ability to connect to a larger communication system with many inputs and outputs will be guaranteed by buffer storages.

A total of 208 offices in 80 cities on United's 14,000-mile network will be connected into the system. This means that more than 2,500 ticket sales agents in the U. S. will be able to literally put their finger on all United flights for one full year ahead.

Company Outlooks

(Continued from page 56)

that the second half of 1958 will bring an upturn" (Don G. Mitchell to shareholders of Sylvania Electric Products, Inc.).

Sales increased 62 percent, earnings 41 percent; a vigorous research and engineering program was refreshed with an outlay of $2.3 million, more than $900,000 above the amount spent last year (George I. Long to stockholders of Ampex Corp.).

Here was the financial story on the late closers:

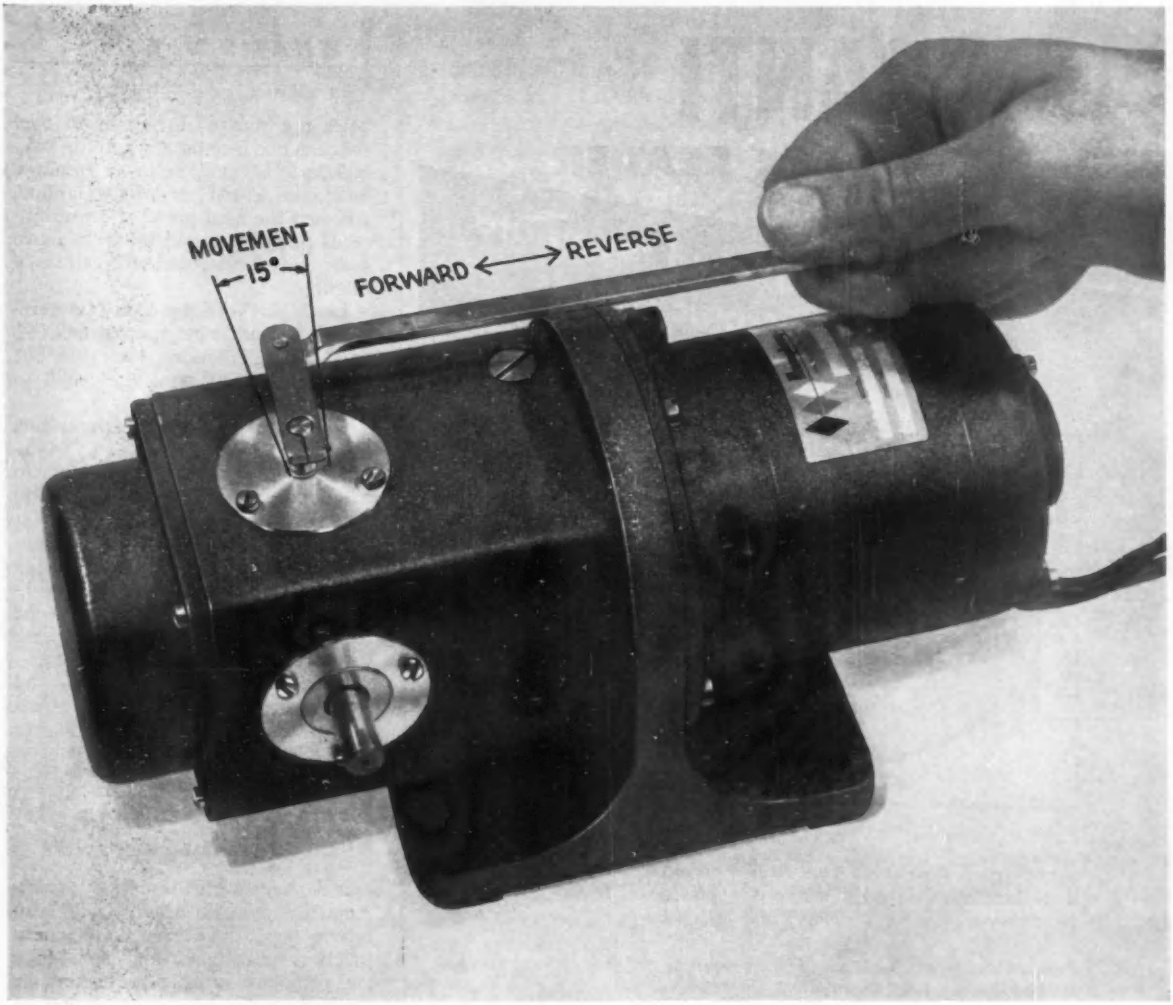
Ampex Corp.—Sales up from $18,737,100 to $30,115,000; net earnings up from $1,087,000 to $1,540,000; backlog at $11.5 million.

Automation Instruments, Inc.—Sales up from $869,141 to $869,828; net profit down from $46,491 to $44,685; backlog for aluminum foil wound solenoids alone more than $100,000.

Daystrom, Inc.—Sales up from $74,402,000 to $81,714,000; earnings down from $2,495,000 to $2,333,000.

General Instrument Corp.—Net sales up from $33,254,735 to $39,195,749; net income up from $505,407 to $1,020,840; working capital up from $8,896,514 to $11,548,181.

Laboratory for Electronics, Inc.—



Get instantaneous response for automatic control with Servotran variable speed drive

The Servotran offers frequency response equivalent to a hydraulic system and *triple* that of an electrical system in a dependable mechanical drive. In less than one-tenth second, a Servotran can be shifted from full speed forward to full speed backward without disengagement of load. Maximum movement of the control shaft is only 15°. Only a few ounces pressure is required on the push-rod control. Performance like this makes the Servotran the perfect variable speed drive for automatic control applications in the 1/70 to 1/4 hp range.

HERE ARE MORE EXCLUSIVE SERVOTRAN FEATURES:

- Repeatability and accuracy of speed setting within ½%.
- Makes ideal integrator for computer and weighing systems.
- Output torque constant.
- Efficiency between 85 and 95%.
- Speed infinitely variable over full range.
- Drive disc and output drum run in oil for extra long life.
- Available with solenoid-operated instant electric shift.
- Available with accurately calibrated dial for manual adjustment.

Write today for information on how you can apply this revolutionary new drive.

Humphrey Inc.

HUMPHREY PRODUCTS DIVISION

DEPT. C-98, 3794 ROSECRANS STREET, SAN DIEGO 10, CALIFORNIA

SEE THE SERVOTRAN AT THE ISA SHOW
PHILADELPHIA
SEPTEMBER 15-19
BOOTH 844

CIRCLE 150 ON READER-SERVICE CARD

FERRANTI

HIGH SPEED TAPE READER

...handles punched tape data at electronic speeds



The Ferranti High Speed Tape Reader accelerates to full speed within 5 milliseconds and stops within 3 milliseconds. It has achieved a sound reputation for simplicity and reliability in regular operation.

Proven Reliability in hundreds of data processing and data transmission installations from coast to coast.

Photoelectric Sensing uses "pin hole camera" optical system for increased signal/noise ratio with any type of fully punched tape; no lenses or mirrors. Output signals greater than 20 volt.

Rugged Differential Type Friction Drive eliminates sprocket hole wear and requires very little maintenance.

Stop-on-a-Character feed mechanism allows operation in any mode from free run to stop on every character at *any* speed up to 200 characters/sec. Feed speed controlled by equipment receiving data. Tape positioned by sprocket hole associated with character being read, eliminating errors due to variations in character pitch. Higher speed models available for 400 characters per second, stopping on or before next character.

Simple Tape Loading with no threading. Character being read is visible to operator. Lap or butt splices accepted.

No Minimum Tape Length. Compatible motorized spooling units available for lengths up to 1,000 feet.

Desk or Console Mounting for comfortable operation.

Size 9" x 11½" x 11¼", Weight 37 lbs.

Consult Ferranti Electric for any paper tape reading problem.

FERRANTI

FERRANTI ELECTRIC, INC.

30 Rockefeller Plaza New York 20, N. Y.

CIRCLE 151 ON READER-SERVICE CARD

WHAT'S NEW

Sales up from $7.1 million to $9.4 million; net income down from $85,000 to $51,000. The lower earnings, said President Henry W. Harding, reflected the final phase of a readjustment program started more than two years ago. Prospects are extremely bright.

Leeds & Northrup Co.—Net earnings down quite a bit, from $1,649,152 to $1,112,127; backlog down, too, but not as sharply, from $13,208,000 to $11,049,000.

Miniature Precision Bearings, Inc.—Sales up from $3,864,000 to $5,486,000; net profits up from $242,000 to $297,000; backlog (as noted above) more than $1 million.

Sylvania Electric Products, Inc.—Sales up from $332,344,159 to $342,957,061; net income down from $14,835,389 to $12,655,839 (decrease due to higher R&D and manufacturing costs, and price competition).

Topp Industries, Inc.—Sales up from $9,009,729 to $10,332,399; total net profits up from $466,796 to $879,874.

New ISA Practices Cover Metal and Glass Rotameters

ISA has issued tentative recommended practices dealing with the terminology, dimensions, and safety practices for indicating metal-tube and glass-tube variable-area meters, or rotameters. Sections cover scope of the practices, uniform connection dimensions, uniform nomenclature, and uniform safe working pressures. RP 16.1 (glass) and RP 16.2 (metal) are available from The Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pa.

FIER Considers Offering More Control Fellowships

The two participating fellowships in control technology awarded recently by the Foundation for Instrumentation Education & Research represent a 100 percent increase over the number of fellowships FIER gave in 1957, its first year of operation. Now the foundation is thinking of boosting the number of awards again, this time to 10, and making them the subject of a nationwide competition. A three-man team is studying the possibilities; it will make recommendations at the annual meeting this month.

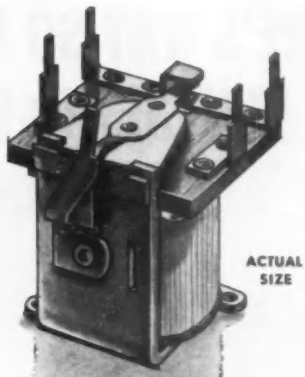
Matching donations for one of the

RBM

TYPE MS

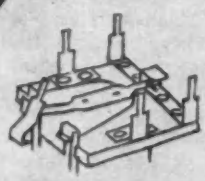
MINIATURE SENSITIVE RELAY

Millions of Type MS relays now in extensive use in highly competitive markets—automotive, radio, and television. Proven ideal for applications requiring a sensitive, highly reliable single pole or common multiple contact DC unit. Mass production, and RBM's experience in assembly techniques, make Type MS your *low cost* solution for volume usage.

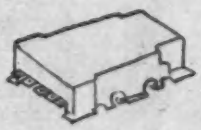


ACTUAL SIZE

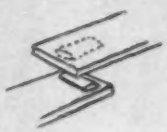
BUILT TO WITHSTAND EXTREME ENVIRONMENTAL CONDITIONS AT **LOW COST**



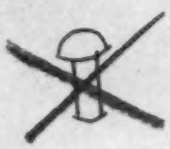
AVAILABLE WITH PRINTED CIRCUIT TERMINALS



ENCLOSED CONTACTS WHERE DESIRABLE



X-BAR CONTACTS INSURE MAXIMUM RELIABILITY



NO CURRENT-CARRYING RIVETS



COIL CONSTRUCTION MEETS UNUSUAL CLIMATIC CONDITIONS

CHARACTERISTICS

	MS-40	MS-25
COIL RESISTANCE	TO 10,000 OHMS	TO 15,000 OHMS
MAX. COIL POWER	1 WATT	1.5 WATT
MIN. COIL POWER	.40 WATT (SINGLE POLE)	.025 WATT (SINGLE POLE)
CONTACT RATING	1 AMP. 28V D.C. OR 115V A.C. (NON-INDUCTIVE)	1 AMP. 28V D.C. OR 115V A.C. (NON-INDUCTIVE)

CONTACT FORMS

SINGLE POLE	COMMON MAKE
NO	3NO & 1DT
NC	5NO
DT	

TERMINALS

(A) SOLDER TYPE - ALL VERSIONS

(B) PRINTED CIRCUIT TYPE (SINGLE POLE VERSIONS ONLY)

Consult your local RBM Product Application Engineer or write for Bulletin MS-3

RBM Division

ESSEX WIRE CORPORATION, LOGANSPORT, INDIANA

CIRCLE 152 ON READER-SERVICE CARD

HERE'S WHY SO MANY ENGINEERS SPECIFY P&B's MH RELAY



Shown with printed circuit terminals

VERSATILITY and adaptability are prime reasons why designers have made the MH a P&B best seller for such diverse applications as jet aircraft, street lighting equipment, computers and missile ground controls.

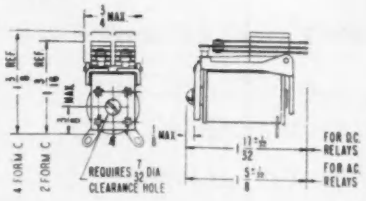
When multiple switching is required ... when size, weight, long life and reliability are critical ... our MH relay can usually fill the bill.

Let us send you complete information. Write or call today.

ENGINEERING DATA/MH RELAY

Insulation: Laminated phenolic.
Insulation Resistance: 100 megohms minimum.
Breakdown Voltage: 500 volts RMS between all elements.
Shock: Up to 30g.
Vibration: Up to 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps.
Ambient Temperature: —45°C. to +85°C. (—65°C. to +125°C. on special order).
Weight: 2½ oz. max. (open relay)
Pull-In: Approx. 75% of nominal voltage.
Pull-In Speed: Approx. 15 ms.
Drop-Out Speed: Approx. 10 ms.
Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

CONTACTS:
Arrangements: Up to 9 springs per stack.
Material: ⅛" silver; also Palladium or gold alloy.
Load: Dry circuits to 5 amps @ 115V AC resistive.



COILS:
Resistance: 22,000 ohms max.
Power: 100 milliwatts per movable minimum to 4 watts at 25°C. max. (200 mw. min. to meet max. shock/vibration spec.)
Duty: DC: Continuous. AC: Intermittent (2 pole relay max.)
Voltages: DC: Up to 110 volts. AC: Up to 230 v. 60 cycles.
Current: 2.5 ma to 10 amps DC.

P&B STANDARD RELAYS AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

CIRCLE 153 ON READER-SERVICE CARD

fellowships just awarded were The Hays Corp. and Panellit, Inc.; for the other, Daystrom, Inc. The winners will study at Purdue and MIT.

The great number of worthy but needy students stimulated FIER to expand its fellowship activities in 1959. The investigating committee just named to look into the matter consists of Robert J. Jeffries, president of ISA; Augustus B. Kinzel, vice-president for research, Union Carbide Corp.; and Elmer Hutchisson, director of the American Institute of Physics.

New Companies in the Field

Lerma Engineering Corp., specialist in applying optical techniques in control engineering—in Northampton, Mass. President John L. Maulbetsch and Vice-President John J. Lerse were both formerly with Kollmorgen Optical Corp., Maulbetsch as vice-president and general manager in charge of optical design, and Lerse as chief development engineer in charge of industrial periscopes. Products of Lerma will include remote viewing instruments, special periscopes and borescopes, optical tooling, inspection devices and optical systems.

Pyrometer Co. of America, manufacturer of thermocouples and pyrometric accessories—in Penndel, Pa. Officers include John V. Metzger, president; Leonard Bonn, vice-president, and Edward R. Stroik, chief engineer.

Don Romine Associates, to design and build environmental test equipment for checking out space vehicles—in Westbury, N. Y. General manager is Donald E. Romine.

New Divisions and Groups

An Advanced Programming Development Group, at Berkeley, Calif., for **Bendix Aviation's** Computer Div. Its current project: development of compilers for the G-15D general-purpose computer system. In charge of the new group is Harry D. Huskey, associate professor of EE and mathematics at the University of California.

A new Research Dept. in Bendix's Radio Div., headed by Milton A. Chaffee, formerly director of electronics and systems research for Fairchild Camera & Instrument Co. Before joining Fairchild, Chaffee was deputy director of the Electronic Research Dept. at the Air Force Research Center in Cambridge, Mass.

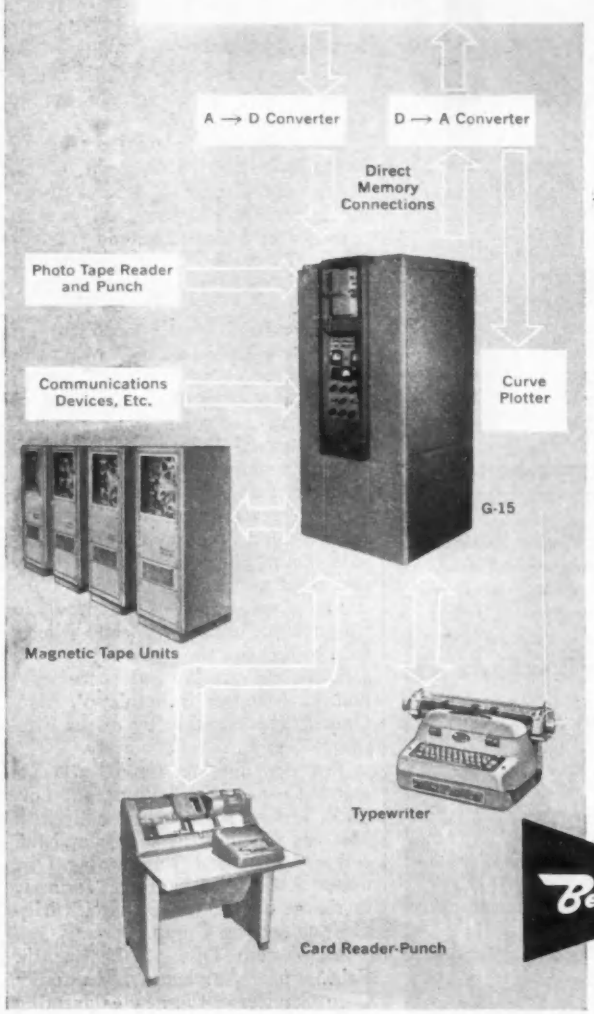
Two new divisions at W. L. Max-

Bendix G-15

the ideal computer for "on-line" data processing and control

TYPICAL SYSTEMS WHERE THE G-15 CAN BE USED

1. *Process controls*
2. *Missile tracking and impact prediction systems*
3. *Engine test stand data reduction and control*
4. *Wind tunnel data reduction and control*
5. *Real time position determination for mobile missile launching sites*
6. *Machine tool controls and many other open and closed loop systems*



In use *now*, as a part of several systems, the Bendix G-15 has proven itself the ideal digital computer for data reduction and control. Its high speed...versatile command structure... widely varied methods and means of input and output... small physical size...and its low cost, all contribute to the *reason* why the G-15 is being selected for use in more and more on-line applications.

The G-15 is the fastest general purpose computer in the low price field. For real-time control applications, this speed is often important. In at least one case the G-15 has been chosen for real-time computation where only a million dollar computer has ever been used before.

The versatility of the G-15's basic programming system contributes heavily to its ability in on-line applications. Commands are available for shifting with tally, extracting and assembling of words, overflow indication, branching, block data transfer, and many other special functions valuable in on-line use.

Perhaps of greatest importance is the computer's unique variety of input-output possibilities. The basic G-15 includes an electric typewriter for input-output and control, as well as a paper tape punch and magazine loaded high-speed photoelectric tape reader. Punched card, and magnetic tape units are available and all may be connected at the same time through the computer's buffered input-output registers.

Other devices such as A to D or D to A converters may be connected simultaneously or in place of the above mentioned accessories, and operated under control of the computer.

Finally, information can be directly written on or read from the memory drum, under control of special external devices.

Note that all of these methods of input and output can be utilized without any modification of the computer. Connectors are provided on the rear of the G-15 for each type of input and output described.



If ruggedness is required, the G-15 can prove an enviable record. Two of them have been in use for well over a year bolted directly to the deck of a ship, and have shown a performance record to be envied by any computer based on solid ground. During a recent six months period the average up-time for all of the over 100 Bendix G-15's in the field was 95.4%.

The G-15 is compact, too, occupying just six square feet of floor space. Of course, it can be used as a powerful general purpose computer, as well as for on-line applications. A variety of simplified programming systems is available, including the renowned INTERCOM 1000, which can be used after four hours training or less.

The reasons are many...but the fact is that more and more G-15's are being leased or purchased for on-line use. If you would like to discuss your own requirements, we would be pleased to work with you. Write Department W-6 for information.

If you are going to the ISA show, our specialists and the G-15 will be there in booths 1440-1541.

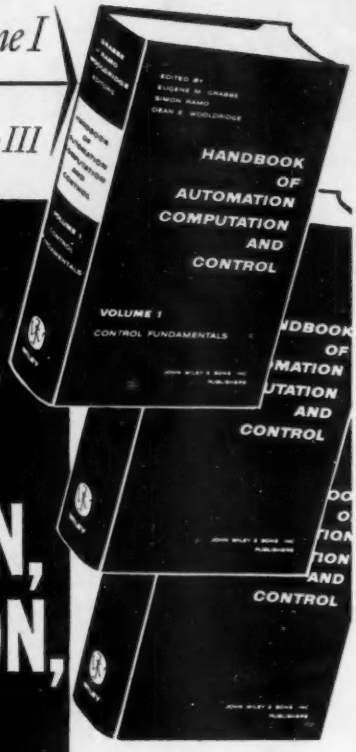
Bendix Computer

DIVISION OF BENDIX AVIATION CORPORATION
LOS ANGELES 45, CALIFORNIA

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READY NOW–*Volume I*

IN PRESS–*Volume II and Volume III*



HANDBOOK OF AUTOMATION, COMPUTATION, AND CONTROL

Edited by
EUGENE M. GRABBE,
SIMON RAMO,
and
DEAN E. WOOLDRIDGE,

all of the
Ramo-Wooldridge
Corporation.

Here's the one complete handbook which provides all levels of technical personnel—*including management*—with up-to-date information about automation, computation, and control!

Prepared by a staff of 106 specialists and edited with system engineering emphasis in mind, it is packed with useful data on research, development, and design in the fields of feedback control, computers, data processing, control components, and control systems. For management, the handbook thoroughly covers the available techniques for applying mathematical models and computers to problems of management decisions. Throughout, the stress is on new techniques and components which *you* can use to design and build digital devices, make measurements, and develop control systems. Much of this material has never before been available in handbook form.

Volume I—**CONTROL FUNDAMENTALS**
Includes extensive treatment of operations research and servo theory, information theory and data transmission, mathematics of digital computers, sets and relations, Boolean algebra, probability, statistics—and much more.

1958 1020 pages Illus. $17.00

Volume II—**COMPUTERS AND DATA PROCESSING. In press.**

Volume III—**SYSTEMS AND COMPONENTS. In press.**

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CIRCLE 155 ON READER-SERVICE CARD

WHAT'S NEW

son Corp., to handle the sales and production work of the dissolved Maxson Instruments Corp. They are: the Langevin Div., Long Island City, N. Y. transformer manufacturer, headed by Albert Schneider, and the Instruments Div., specialist in oscillators, phase-meters, acceleration sensing devices, and other control items, in charge of Michael J. Grassi.

Daystrom, Ltd., of England, a new division of **Daystrom International,** to manufacture a complete line of Heathkit packages for electronic test equipment, audio and high-fidelity sets, and ham radio operators. A. E. B. Perrigo, formerly with Parkinson & Cowan Instruments of England, is managing director.

A Military Products Div. for **Benson-Lehner Corp.,** to undertake contracts for electronic subsystems and assemblies, and ground-support and test equipment. Manager is Harold J. Rounds Jr., vice-president and general manager of Benson-Lehner, and chief engineer is Joseph M. Cahn, formerly a project engineer in the Data Instruments Div.

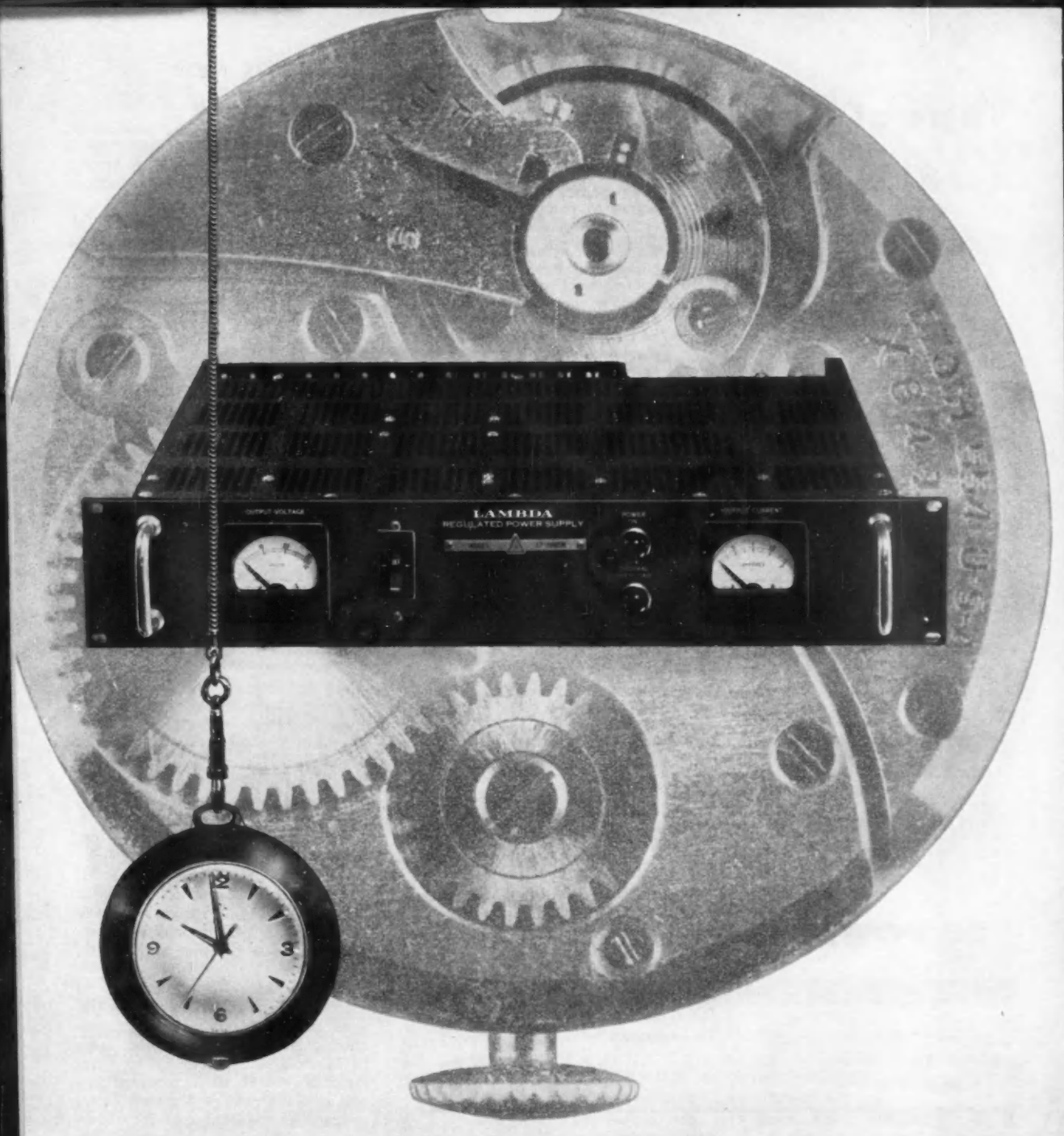
An ATOHM Electronics Div. for **Bruce Industries** of Gardena, Calif., headed by George Elliott, formerly executive vice-president and general manager of Dale Electronics Corp.'s Pacific Coast Div. Elliott designed all of Dale's miniature trimmer potentiometers.

A new R&D center (its fifth) for **Robertshaw-Fulton Controls Co.,** this one to be called the Eastern Research Center and to be built in King of Prussia, Pa., 14 miles from Philadelphia. General Manager is Ralph V. Coles, formerly in charge of the Instrument Div. Also scheduled: a new product development laboratory for R-F's Fulton Sylphon Div. in Knoxville, Tenn. Supervisor is J. P. Wagner, chief project engineer.

An Engineering Laboratory in Monterey, Calif., for **Dalmo Victor Co.,** to broaden the parent company's activities in missiles and space technology. Manager is Frank W. MacDonald, formerly director of the Firestone Engineering Laboratory.

Two new divisions for **Atlantic Research Corp.,** a Solid Propellant Div. under Presson S. Shane, formerly with McGean Chemical Co. of Cleveland, and a Mechanical Engineering Div. under Robert O. Webster, formerly in charge of Atlantic Research's Missile Engineering Group.

A Western Div. at Chatsworth, Calif., for **Amphenol Electronics Corp.** Services of the new engineering



Guaranteed: around-the-clock performance for five years

Freedom from worry about major maintenance or extensive replacement for *five full years.* That's the guarantee given with every Lambda power supply—the first such guarantee in the electronics industry. It proves the point engineers keep making in preference studies: When operating conditions make dependability a "must," they specify Lambda...
To check the full Lambda line yourself, send for the latest catalog.

LAMBDA POWER SUPPLIES

LAMBDA ELECTRONICS CORP., 11-11 131 STREET, COLLEGE POINT 56, N. Y.

CIRCLE 156 ON READER-SERVICE CARD

specialized keyboards



Any number of keys in any arrangement you require – wired to your specifications – in a rugged steel case.

Concord Keyboards are particularly designed for reliable operation and specialized layout. Each key operates two normally open and two normally closed contacts simultaneously for maximum circuit flexibility. Key activated switches are rated for over 20 million cycles. Key action is positive, no adjustment or lubrication is necessary.

Typical example – $195.00 for a fourteen key keyboard wired to 4 foot cable and a Cannon connector. Case painted green. Delivery 3 weeks.

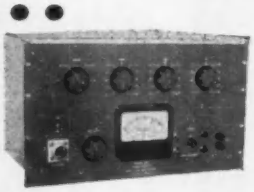
Send us a sketch of your desired key layout and wiring specifications. We'll send you an estimate by return mail.

Concord Control Inc.
1282 Soldiers Field Road, Boston 35, Mass.

CIRCLE 157 ON READER-SERVICE CARD

STABILITY...

with jf *High Voltage – High Resolution*



DC POWER SUPPLIES

Model 405 shown

MODEL	405	404M	403M
OUTPUT	600 to 3100 VDC 0 to 15 ma	500 to 2000 VDC 5 ma to 1500 V 2 ma to 2 KV	500 to 1600 VDC 0 to 1 ma
REGULATION	.01% line .01% load	.01% line .03% load	.03% line .03% load
STABILITY	.005% per hour	.005% per hour	.02% per hour
RESOLUTION	10 mv at any output	100 mv at any output	100 mv at any output
CALIBRATION ACCURACY	Better than .5%	Better than 1%	Better than 2%
PRICE F.O.B. Seattle	$595.00	$435.00	$220.00

For full details and specifications on these and other models to meet your particular needs, contact our representative or write to:

JOHN FLUKE MANUFACTURING CO., INC.
1111 W. NICKERSON ST., SEATTLE 99, WASH.

CIRCLE 158 ON READER-SERVICE CARD

and sales group will be beamed at Southern California, southern Nevada, and Arizona. James H. Schaefer, formerly head of Amphenol's Los Angeles office, is general manager.

An Engineering R&D Dept. at Richmond, Calif., for **Kaiser Industries'** Kaiser Aircraft & Electronics Div., supplier of aircraft and missile components and assemblies. Its new department gives the Richmond plant equal status with Kaiser's electronics plants in Palo Alto, Calif., Phoenix, Ariz., and Toledo, Ohio, which have already expanded their engineering services and are now doing R&D work in missile checkout and flight generator systems, and systems for flat television tubes.

Acquisitions

United Electronics Co. of Newark, N. J. (thermionic tubes and vacuum capacitors, including a brand new line of ceramic variable vacuum capacitors for high-power frequency applications), by **Ling Electronics, Inc.** United's President Charles A. Rice and Vice-President John R. Beers (research and engineering) stay on under the terms of the purchase.

Claud S. Gordon Co. of Illinois, Richmond, Ill., maker of insulated thermocouple wire and accessories, by **Cleveland Pneumatic Industries, Inc.**

The Electrolizing Corp. of Providece, R. I. (a process for treating metals) by **Advance Industries, Inc.**

The **Electronics Div.** of Hall-Scott, Inc., by **Mandrel Industries,** which has assigned it to the Sequoia Wire & Cable Div. A 300-man staff will operate the new acquisition at Burbank, Calif.

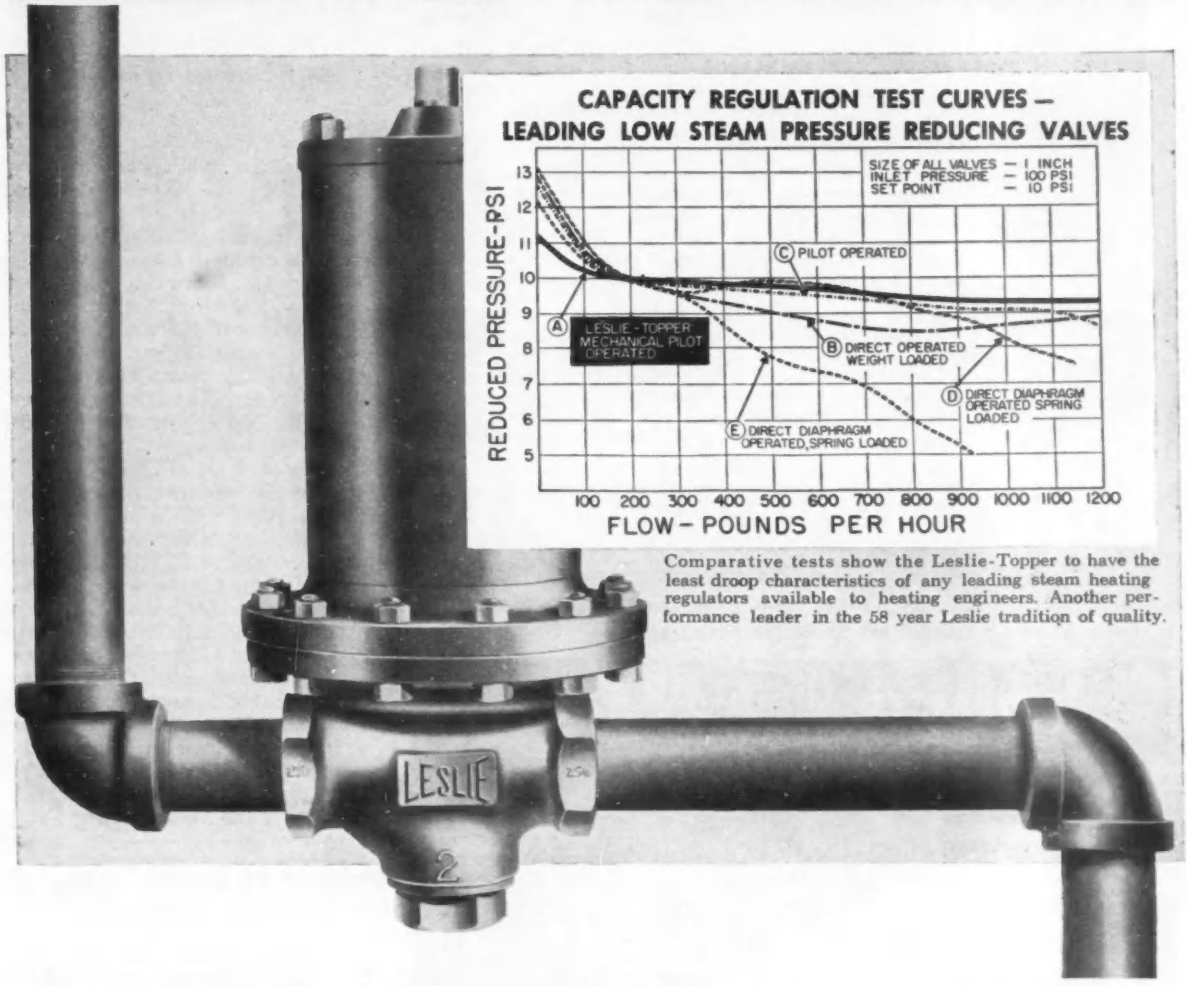
The General Ultrasonics Co. of Hartford, Conn. (R&D work in ultrasonic processing, plating, and homogenizing) by **Acoustica Associates, Inc.,** of Mineola, N. Y., and Culver City, Calif. Stanley R. Rich, president and technical director of General Ultrasonics, and co-inventor of the Ultraviscoson, will continue to head his company's research activities. Acoustica recorded sales of $1,096,760 for the fiscal year ended in February.

Merger

Crescent Petroleum Corp. of Tulsa, Okla., petroleum and gas producer which also has petrochemical operations, and **Norbute Corp.** of New York City, manufacturer of electrical and electronic equipment.

revolutionary pressure reducing valve with mechanical pilot out of steam path

ELIMINATES MAINTENANCE



Comparative tests show the Leslie-Topper to have the least droop characteristics of any leading steam heating regulators available to heating engineers. Another performance leader in the 58 year Leslie tradition of quality.

Now . . . a mechanical pilot operated reducing valve with direct operated simplicity and steam pilot accuracy . . . proven in comparative tests with other leading regulators a new concept in maintenance-free steam pressure reduction . . . the LESLIE-TOPPER

- Inlet pressures from 7 to 250 psi — reduced pressure ranges from 2 to 35 psi.
- Sizes ½", ¾", 1", 1¼", 1½", and 2".
- Piloting device entirely outside the path of steam.
- No dirt catching or close fitting parts — Use it for intermittent, continuous or standby service with complete confidence.
- Packless construction.
- Long life, long travel, *metal* diaphragm.
- Single-seated stainless steel main valve, hardened to 500 Brinell, seats on renewable *stellited* stainless steel seat ring for tight shutoff.
- No auxiliary operating air required.

All of this adds up to new reliability, freedom from maintenance and shutdown time. All of these extra quality features are available at less initial cost than any steam pilot or direct operated regulator you would endorse with your specification.

Eliminate your steam heat reducing valve problems this year, this heating season; write *now* for all the facts, including complete capacity-regulation data — or phone your Leslie representative. You'll find him listed in your classified directory.

TRADE LESLIE MARK

REGULATORS and CONTROLLERS

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Advanced INSTRUMENTATION

ELECTRONIC TACHOMETER and FREQUENCY COUNTER

For Precise In-Line Numerical Indication



Model 1292

Self-contained readout or choice of remote indicator styles including explosion-proof types. Several models available in 4 or 5-digit readout for accurate indication of frequency, speed or flow • Digital count down time base • Input—Sine Wave: 5 to 150,000 CPS. Pulses: 0 to 150,000 CPS • Display Time: From .1 to 10 seconds • Time Bases: .1, .5 and 1 second (specials available) • Sensitivity: 50 MV RMS (5 MV optional) • Electronically regulated power supply.

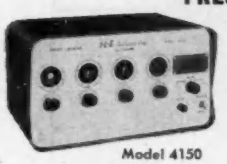


Model 1610

PORTABLE DECADE COUNTER

Low cost 4 or 5-digit models for RPM or frequency counting, totalizing and time interval measurement • .1 and 1 second gate times (specials available) • AC signal or photo-cell inputs • Accessory socket furnishes power to external equipment.

PRESET COUNTER for Automatic Control



Model 4150

For high speed counting and control in automatic operations. Panel switch permits use as totalizing counter at rates up to 5000 per second, or as preset counter with rates to 1000 per second • Optional batch counter (5-digit register shown) totalizes batches at rates up to 600 per minute • Inputs for magnetic or photo-electric pickups.

Technical details for all models are available at your request.

Electrical & Electronic Tachometers • Magnetic & Photo-electric Pickups • Electronic Timers
Electronic Counters • Explosion-proof Housings • Power Supplies • Custom Test Equipment

I-L-S *Instrument Corp.*

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CIRCLE 161 ON READER-SERVICE CARD

WHAT'S NEW

IMPORTANT MOVES BY KEY PEOPLE

Thompson-Ramo-Wooldridge Names Johnson to Key Post

Ralph P. Johnson has been named head of all research, engineering, manufacturing, and administrative activities at The Ramo-Wooldridge Corp. except those having to do with Space Technology Laboratories and The Thompson-Ramo-Wooldridge Products Co. These two companies, organized just before the Thompson-Ramo merger (CtE, Aug., p. 19), will report separately to President Dean E. Wooldridge. Johnson, formerly vice-president for R&D, will function under the official title of group vice-president in charge of the General Electronics Group of Divisions.

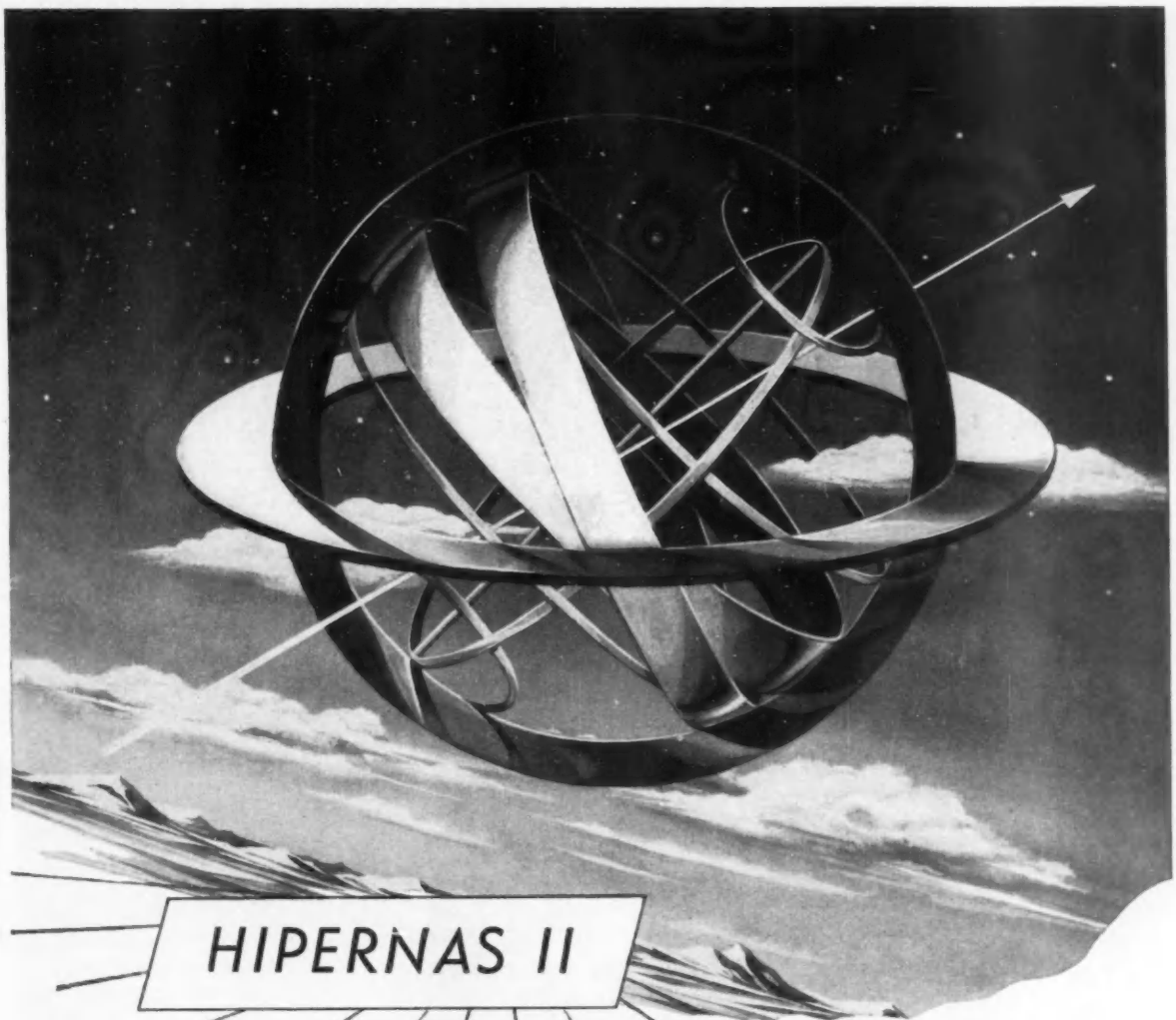
Other vice-presidents named to new responsibilities in the Ramo-Wooldridge segment of the combined companies are Burton F. Miller, formerly director of the Communications Div., who becomes director of advanced planning; Milton E. Mohr, formerly director of the Control Systems Div., now in charge of engineering and head of the Control Systems, Communications, and Electronic Instrumentation divisions; and Irwin A. Binder, formerly head of manufacturing, who takes over the Denver-Los Angeles activities of the Manufacturing Div.

Silva Heads Special Team at Beckman Systems Div.

L. M. Silva, who has been with Beckman Instruments' Systems Div. since 1954, has been named head of a new senior technical staff for the division. Working with him will be W. J. Chalmers, appointed chief of components R&D, and H. G. Preston, chief of systems engineering. Purpose of the new unit is unique; it is to apply creative manpower in depth to the development of industrial data processing and control systems.

"The new organizational pattern welds highly specialized personnel into a technical team responsible for systems design, development, and installation," explained Division General Manager John F. Bishop. "With the scope of present technology, systems development no longer is a one-man job."

Other members of the staff, and their areas of particular ability, in-



HIPERNAS II

A new concept in advanced INERTIAL NAVIGATION SYSTEMS

Bell has outstanding opportunities for experienced engineers and scientists in the following areas:

- Inertial navigation system analysis and design
- Design and evaluation of gyros and accelerometers
- Airborne digital computer application
- Inertial test equipment development and design
- Transistorizing of analogue and pulse circuitry
- Advanced design and packaging

Assignments embrace a high level of design and development problems. Learn about the personal opportunities and unexcelled benefits now available to you on this challenging program. Send resume of your qualifications to: Supervisor of Engineering Employment, Dept. F-47, BELL AIRCRAFT CORPORATION, P. O. Box One, Buffalo 5, New York.

Niagara Frontier Division

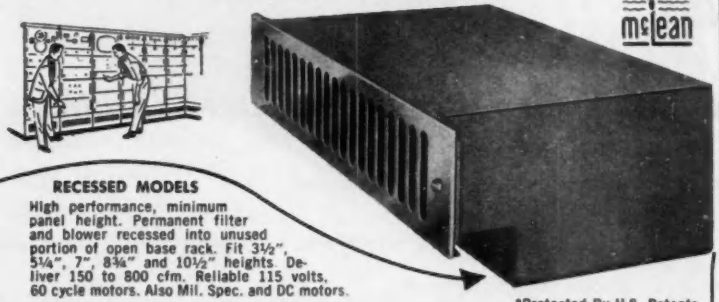
BELL Aircraft CORP.



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COOLS RACKS

SAVES SPACE TOO!



RECESSED MODELS

High performance, minimum panel height. Permanent filter and blower recessed into unused portion of open base rack. Fit 3½", 5¼", 7", 8¾" and 10½" heights. Deliver 150 to 800 cfm. Reliable 115 volts, 60 cycle motors. Also Mil. Spec. and DC motors.

*Protected By U.S. Patents

McLean Fans & Blowers*

FOR ELECTRONIC APPLICATIONS

RACK MOUNTED FOR EASY ASSEMBLY • FIT STANDARD 19" RACKS
STANDARD MODELS FOR OTHER RACK WIDTHS AND ANY ANGLE OF AIR DISCHARGE

Over 15 models available in panel heights of 3½" to 12¼" in increments of 1¾" . . . range 80 to 1200 CFM

Install McLean Fans and Blowers in computers, control units, etc. McLean's small packaged units pressurize cabinet with cool filtered air, keeping dust out. Complete in one unit and ready for use. Standard RETMA notching allows mounting on rack . . . without cutting or fitting. Smart stainless steel grilles . . . easily removable filters.

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Agents in Principal Electronic Manufacturing Areas

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WHAT'S NEW

clude K. L. Chien, digital computers and automatic control equipment; P. R. Gilson, high-speed input-output equipment and data processing techniques; J. A. Tillotson, advanced data acquisition and check-out systems; J. H. Doyle, design and application of analog components; S. F. Molner, systems organization and design; W. V. Smith, computer programming; W. F. Kamsler analog systems design.

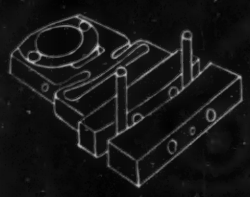
Research Specialist Steers Midwestern R&D Program

William H. Duerig, picked by Midwestern Instruments, Inc., to supervise an accelerated R&D program and a complementary product expansion, is the man who developed the fm subcarrier discriminator for missile and aircraft ground telemetering stations. He was also instrumental in the adoption by the Research & Development Board of fm/fm telemetering systems as a standard for most missiles and aircraft testing programs. Duerig comes to his new assignment from Electro-Mechanical Research, Inc., where he was head of the Engineering R&D Div. Before that he was with the University of California's Radiation Laboratory, working on the Manhattan Project, and Johns Hopkins University's Applied Physics Laboratory. At Midwestern he will be vice-president for research and engineering.

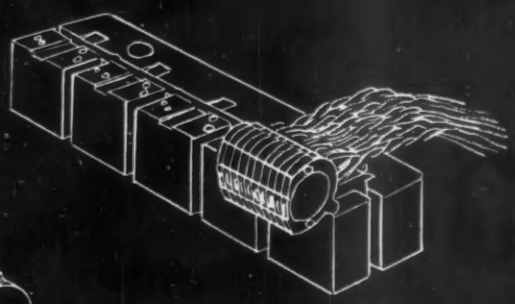
Five New Vice-Presidents Join Busignies at IT&T

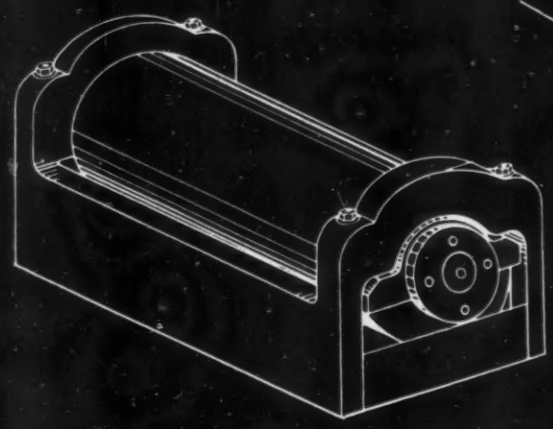
Five new vice-presidents join President Henry Busignies (CtE, July, p. 54) in steering IT&T's consolidated R&D division for electronics and communication. Four, former directors of the Federal Telecommunication Laboratories, one of the organizations involved in the move to bring together all IT&T research laboratories, are Louis A. de Rosa (electronic countermeasures), Sven H. Dodington (avionics), Armig G. Kandoian (communication systems), and Arnold M. Levine (missile systems). The fifth man is Charles D. W. Thornton, formerly director of R&D at Farnsworth Electronics Co., also affected by the change.

IT&T's new Astrionics Laboratory, which will look into the requirements in guidance and control, and in data processing and instrumentation, for missions into space, is headed by Donald M. Culler. This lab, said Busig-



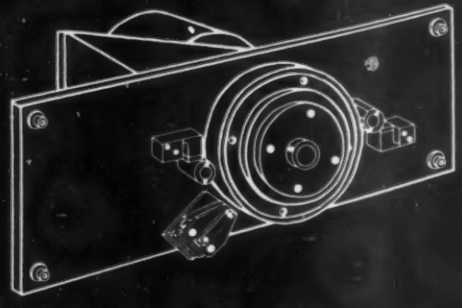
Here are High Performance Components at Budget Prices





Every project engineer can now afford to have his own magnetic storage drum . . . a truly versatile memory system . . . to expedite many jobs. Costing less than the price of a good oscilloscope, a Monrobot modular storage unit offers high performance characteristics with near custom-designed flexibility. Drum speed and head layout may be selected by the systems engineer to meet his individual requirements; belt drive models and open head mounting allow field alteration to accommodate major system changes which require different speeds or delay times. Thus, engineers can "prove out" logic without risk of obsoleting the drum before the system is complete.

Both drums and heads have shown high mechanical stability under rough field conditions and over a wide range of temperatures. The drums, offering information storage at a high density, are rigid and stable with a minimum of run-out. The read/record heads feature built-in fine calibration adjustments and can be adjusted over a delay of forty pulses while the drum is rotating. For complete specifications, write: Monroe, Dept. E, Orange, N. J.

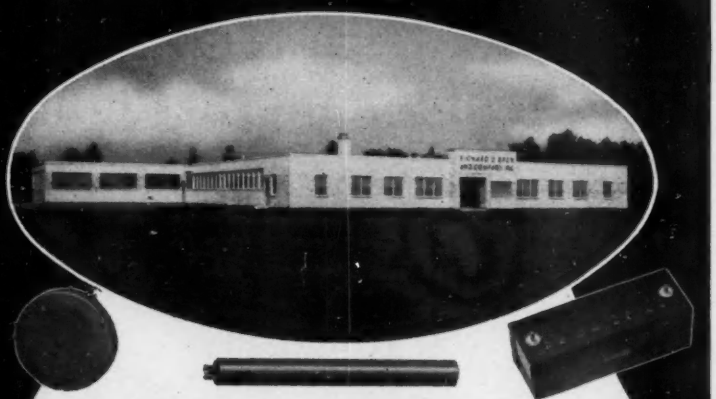


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for CALCULATING
ADDING, ACCOUNTING
DATA PROCESSING MACHINES

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A DIVISION OF LITTON INDUSTRIES, INC.
Offices for sales and service throughout the world

Brew Delay Lines



Brew offers you the "one source" for Distributed Constant, Lumped Constant, and Ultrasonic Delay Lines. You and your product will benefit from Brew's modern and complete production facilities, pioneer experience, and complete cooperation from our personnel.

DELAY LINES DESIGNED TO YOUR SPECIFICATIONS

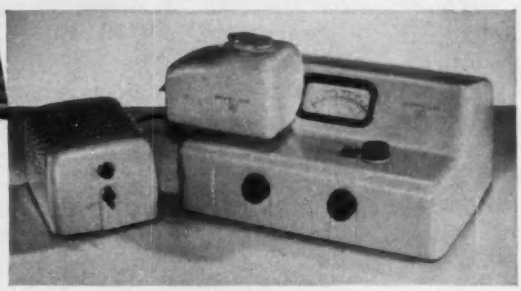
BREW **Richard D. Brew and Company, Inc.**

Concord, New Hampshire

design • development • manufacture

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NEW!



BAUSCH & LOMB

Spectronic

COLOR-ANALYZER

Simplifies precision measurement . . . for identification, control and matching of colors . . . to I.C.I. standards . . . at lowest cost! . . . $515.00 complete.

"Fingerprints" any color for permanent reference • The B&L Spectronic Color-Analyzer determines brightness, hue and saturation *objectively*—by accurate scale readings of percent reflectance. Identification is in terms of world-standard I.C.I. numerical designations. Paints, inks, dyes can be matched to previous production runs. Keeps production to specifications. Applications range from printing to textile finishing to just about any process requiring control of color.

Lowest cost in the entire color-analysis field! • Extremely low cost is made possible by use of the best-selling B&L Spectronic 20 Colorimeter-Spectrophotometer as the basic photometric equipment. Complete equipment—Spectronic 20 Colorimeter plus Spectronic Color-Analyzer accessory—is $515. Spectronic Color-Analyzer accessory alone, for use with any Spectronic 20 Colorimeter, is $280. Compare with any other color-analysis equipment. You won't find any that equal B&L Spectronic performance at anywhere near the low Spectronic price!

WRITE to us today for Catalog D-290 and an obligation-free demonstration. Bausch & Lomb Optical Co., 3 St. Paul Street, Rochester 2, New York.

BAUSCH & LOMB

SINCE B&L 1853

CIRCLE 167 ON READER-SERVICE CARD

nies, whose new R&D group will oversee it, was formed to meet "the many technical problems resulting from the acute accuracy, reliability, and functional requirements of space systems under adverse and unexplored conditions." Some of its current projects:

A radio relay system with "fixed" satellites for world-wide dial telephone and television transmission; an interplanetary navigation system for manned space ships; space-to-earth communication systems using compressed radio bandwidths.

Professional Engineers Elect Dunn, Univ. of Oklahoma

Clark A. Dunn, professor of civil engineering and executive director of the office of engineering research at the University of Oklahoma, Stillwater, Okla., has been elected president of the National Society of Professional Engineers. He succeeds Garvin H. Dyer of Independence, Mo., as head of the 46,000-member group.

Honeywell Shifts Top Men in Industrial Products Group

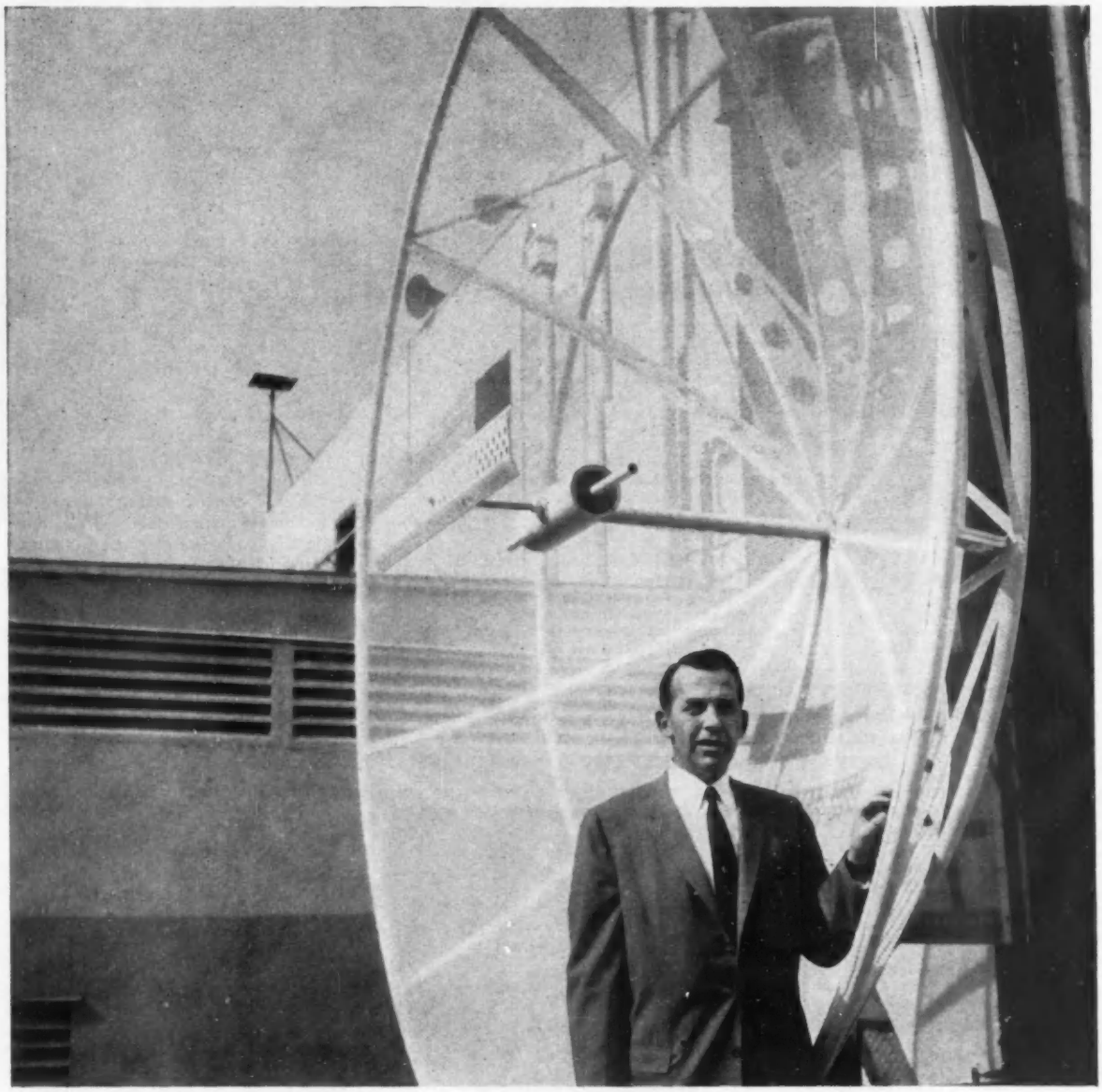
Minneapolis-Honeywell's Industrial Products Group, which directs activities in industrial instrumentation and data processing, has made several executive changes to strengthen competitive position, improve product and customer service, and further assist the field sales force. George M. Muschamp, who was in charge of the Brown Instruments Div.'s Engineering Dept., becomes group vice-president for engineering; John M. Wilson, head of design and development at Brown, takes over Muschamp's responsibilities there as director of engineering; and O. B. Wilson, formerly Brown sales vice-president, is named group vice-president for marketing.

In addition, R. L. Mallory becomes sales manager of the Industrial Products Group and J. A. Robinson and H. Earl Benson become sales managers for Brown and Rubicon, two of the group's divisions.

Muschamp joined Brown in 1930, John Wilson in 1934, O. B. Wilson in 1923, Mallory in 1933, Robinson in 1934, and Benson in 1946.

Other Important Moves

Donald A. Erle has been named chief engineer for fluid control de-



STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

I've been asked whether non-aeronautical engineers have good prospects for advancement in the aviation industry.

The answer is *yes, definitely!* At Douglas many of our top supervisory people have moved up from other engineering specialties. The complexity of modern aircraft and missiles requires the greatest variety of engineering skills known to industry.

For example, we now have pressing needs for mechanical, structural, electrical and electronics engineers in addition to aerodynamicists, physicists and mathematicians. Whatever your background in the engineering profession may be, there are prime opportunities in the stimulating aircraft and missiles field.

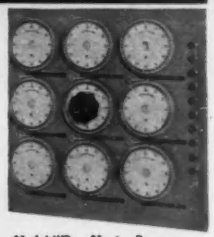
Please write to Mr. C. C. LaVene
Douglas Aircraft Company, Box D-620
Santa Monica, California

NOW . . . A New Design Concept in Multi-Circuit Program Control

ZENITH

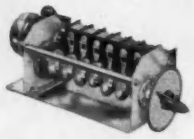
Multi-Circuit

TIMERS



Model WD—Master Programmer

Master programming dials control operation of all circuits and sequencing relationship between circuits in the cycle. Adjustments are easily made on the face of the panel. As many as 48 "on" and "off" operations can be made on any one circuit without disturbing operation of other circuits. Single heavy-duty motor drives entire unit to assure full synchronization of operations and dials.



Model WM—Compact Design

Zenith Multi-Circuit Cycle Timers are available in models and types for all timing, mixing, compounding, processing and similar operations. They can be supplied in any time cycle and any number of switches.

Request details on the Zenith Master Programmer and other multi-circuit timers. Write on company letterhead for complete 64-page catalog describing automatic transfer and remote control switches, magnetic contactors, program clocks and timing controls.

See Classified Directory for Name of Local Representative

ZENITH ELECTRIC CO.

169 WEST WALTON STREET · CHICAGO 10, ILLINOIS

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Governaire
precision pneumatic

PRESSURE REGULATORS for Industry

The facts you need on a complete range of pneumatic pressure regulating valves and volume boosters. Here is your guide to a series of pilot-operated and direct acting regulators—in pipe sizes from ¼ to ⅜ and ¾ NPT...in supply pressures up to 250 psi. Fact-filled pages spell out the full story: characteristics • pressure ranges, ratios • applications—for 16 different models including motor operated and lever set types.

Write today for the new KENDALL- GOVERNAIRE catalog.



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INDUSTRIAL PRODUCTS BRANCH

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A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION

Turbo-Expanders and Compressors

SPECON Variable Speed Drives and Transmissions

Pneumatic Pressure Regulators

CIRCLE 169 ON READER-SERVICE CARD

WHAT'S NEW

vices by The Hydrodyne Corp. He comes to Hydrodyne from Bendix Pacific, where he was in charge of the Hydraulic Design Engineering Group.

Motordyne, Inc., has named **Oscar B. Robey,** formerly chief engineer of Reese & Reese, Inc., of Pasadena, Calif., head of the new Gyro Div., which is readying a complete line of precision gyroscopes for the aircraft and missile industries. Also on tap from the division: several gyro-type devices and special torque motors. Motordyne specializes in fractional horsepower motors and small rotating equipment for industry.

Walter Welkowitz, who joined Gulton Industries, Inc., in 1955, has been appointed director of engineering for the Vibro-Ceramics Div., specialist in industrial ultrasonics and medical-electronic instrumentation. Before coming to Gulton, Welkowitz lectured on and did research in acoustics at Columbia University.

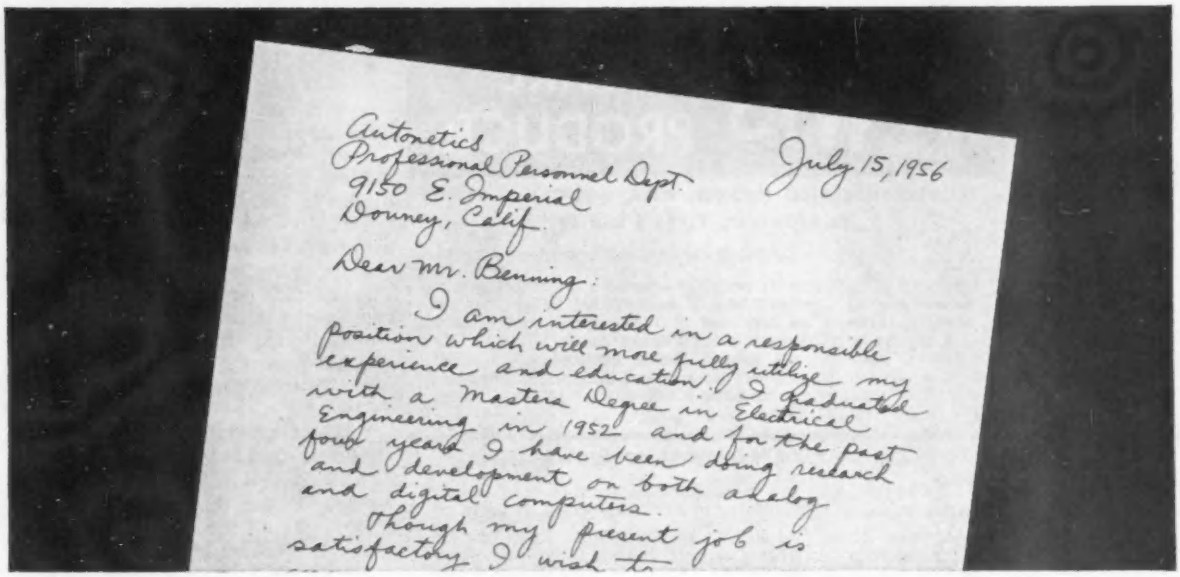
Edward J. Messinger, whose 20 years in engineering include eight as a key man with Bell Aircraft Corp., has been named senior systems engineer in the Weapon System Support Project of Aerophysics Development Corp.

A new technical specialist at Stromberg-Carlson–San Diego comes from Allen B. DuMont Laboratories, where he was senior research engineer and head of the Solid State Physics Section. He is **Arthur Bramley,** patent-holder in electronics and a fellow of the American Physical Society. At DuMont, Bramley was primarily concerned with methods for processing photoconductors.

Lynn Bly, formerly director of manufacturing for Air Logistics Corp., has been named assistant chief engineer for Horkey-Moore Associates. At Air Logistics, Bly was in charge of development, fabrication, and installation of jet-engine test systems; at Horkey-Moore he will help steer work in environmental testing.

Consolidated Electrodynamics Corp. has named **Everett J. Long** director of the Transducer Div.; he had been assistant director of operations in the division. Long came to the company in 1952. Before that year he was with, among other companies, Austin Co. of Denver, Bendix Aviation Corp., and the Los Alamos Scientific Laboratories. He succeeds **Kennett W. Patrick,** named vice-president for the Monrovia (Calif.) divisions (CtE, Aug., p. 47).

Ultronix, Inc., San Mateo, Calif., maker of precision electronic com-



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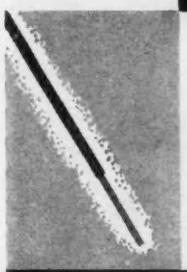
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CIRCLE 171 ON READER-SERVICE CARD

WHAT'S NEW

ponents, has named **John C. Schweitzer** director of research. Schweitzer comes from Boeing Airplane Co., where he supervised development of airborne and ground telemetry systems.

Charles R. Bootz, manager of Black, Sivalls & Bryson's nuclear project at Tulsa, Okla., for the past two years, has been named manager of the Control Div. at Tulsa. Before joining BS&B, he was director of laboratories for Rand Development Corp. of Cleveland.

Adolph O. Schaefer, president of Pencoyd Steel & Forge Corp. of Philadelphia, has been appointed secretary of the American Society of Metals, to fill the unexpired term of the late **William H. Eisenman** (CtE, Aug., p. 48). Assistant Secretary **Ray T. Bayless** has been named manager of the society at its headquarters offices in Cleveland.

Varian Associates' new manager of product development in the Instrument Div. is **Norman Hiestand**, formerly manager of power tube applications in the Tube Div. He came to Varian in 1950, from Stanford University's Microwave Laboratory.

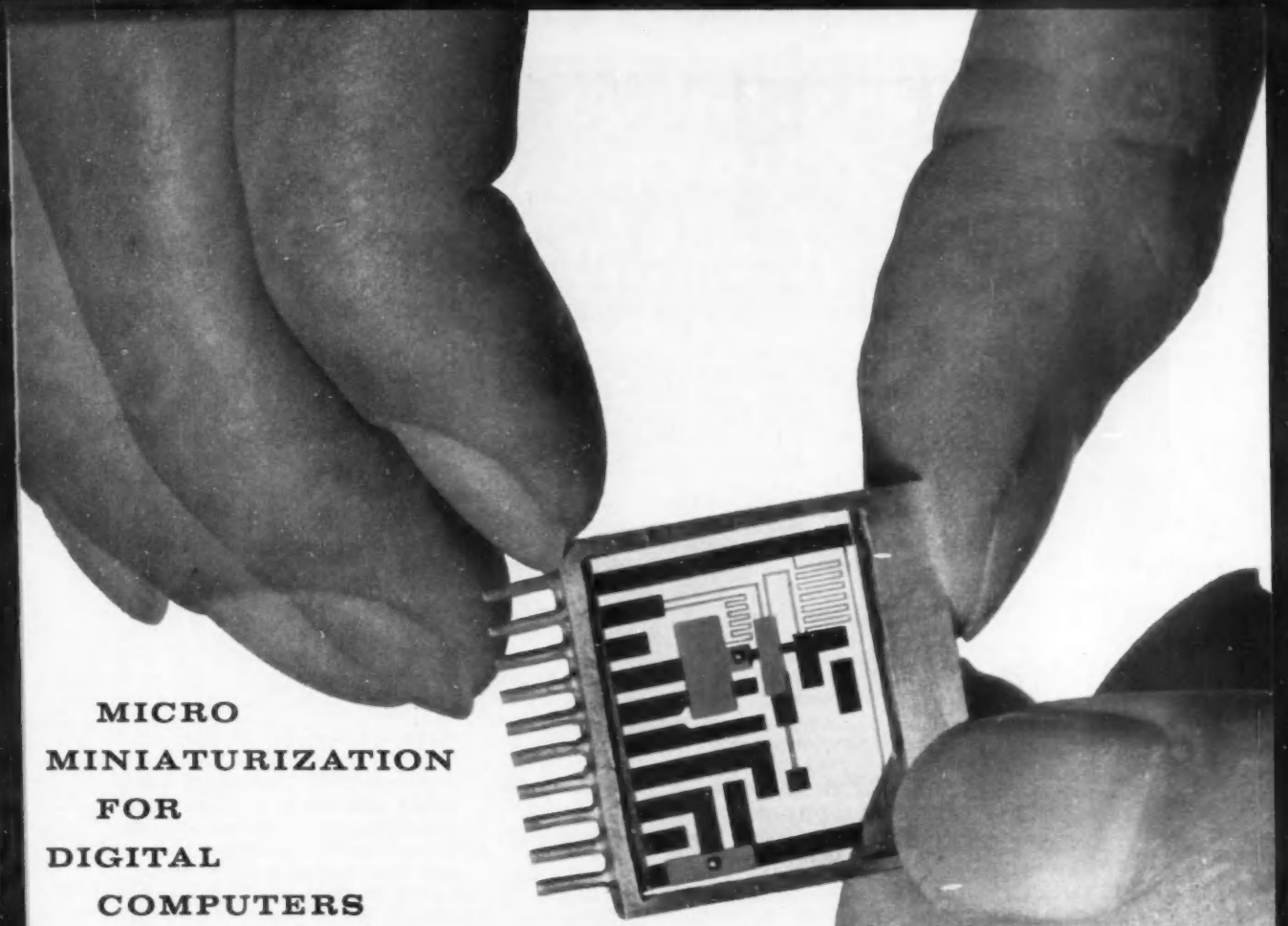
James Peterson, formerly supervisor of special machine design and manufacturing of test equipment at Chance Vought Aircraft, has joined Cyril Bath Co., where as chief engineer he is expected to make significant use of his knowledge of some of the new metals. Before his affiliation with Chance Vought, Peterson was chief engineer of Acton Mfg. Co. of Kansas City, Mo.

The Boston Div. of Minneapolis-Honeywell has named **W. A. Rote**, formerly chief engineer, director of engineering in charge of R&D, preproduction, and product and special engineering.

International Radiant Corp., Westbury, N. Y., designer and manufacturer of environmental test equipment, has appointed **A. L. Busch Jr.** chief engineer, **Paul M. Moscowitz** chief designer, **Bernard Friedman** general manager and technical director, and **Philip L. Stanger** manager of manufacturing. Friedman is national vice-president of the Institute of Environmental Engineers.

Obituary

Clayton W. Work, 65, sales promotion manager for the Instruments & Controls Div. of Hagan Chemicals & Controls, Inc.; of a heart attack while vacationing in New England.



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CIRCLE 172 ON READER-SERVICE CARD

ABSTRACTS

Batch Process Control–III

From "Control and Automatic Regulation of Step Processes" by W. Oppelt, an article in the German publication REGELUNGSTECHNIK, Vol. 6, No. 2, 1958. Last in a series of three abstracts prepared by Sigmund Rappaport, project supervisor at Ford Instrument Co. and adjunct professor of kinematics, Brooklyn Polytechnic Institute.

The characteristics and parameters of control components in continuous processes are usually constant and their connections remain unchanged during the whole operation. Theory is well established and easily applied by the technician. Table I shows some of the symbols developed to represent continuous processes. Signals are carried in the connecting lines continuously from block to block. Respective transfer functions are denoted within the blocks in the form of operational equations, using mainly the frequency response characteristics, in which both input and output values of the block are harmonic oscillations. Often the shape of the transfer function is also drawn in the block.

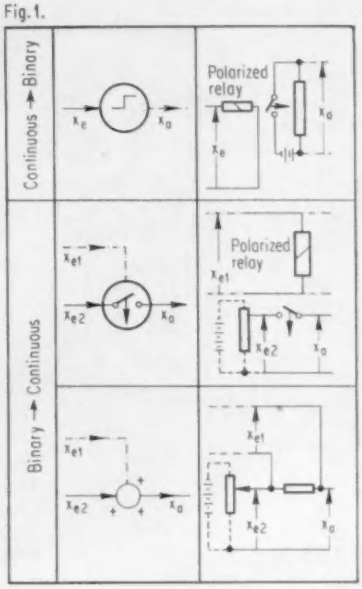
Nonlinear elements, denoted by a circular enclosure, show the characteristic curve. Symbols for branching and merging points complete the notation requirements.

Representation of batch processes

Table I – Symbols for Continuous Processes

Directional signal flow	
Linear component: with frequency response written	$\frac{V}{1+T_1 p}$
with transfer function drawn	
Nonlinear component characteristic drawn in	
Signal branching	
Signal addition	
Signal muliplication	
Sign inversion	

Fig. 1.



is more complex. Additional elements, mainly adaptations of digital computer components, are needed here, because the abrupt changes in input data cause constancy to be replaced by step functions (see Table II). The stepwise process results in additional signal flow channels, which need to transmit only binary signals having

Table II – Symbols for Stepwise Processes

a. Signal flow: binary pulsing	
b. Gate	
c. "and"	
d. "or"	
e. "not"	
f. from which the combination "nor"	
Storage cell	
Storage	Input; Call pulse; Output
Timing switch	or; or

values of 0 (off) and 1 (on). These channels are denoted by dash-dot lines (those of continuously variable signals are solid lines). The symbols for the transition from continuous to binary and vice versa are shown in Figure 1. This figure also contains instrumentation examples for these variations.

Binary signals can be used to repersent fundamental logical operations, e.g., AND switching gives an output if both inputs are present, and OR switching gives an output if either of the inputs is present. NO yields an output when the input is zero and none when the input is one. Relays, tubes, transistors, or magnetic sweep generators are used for these switching circuits.

Intermittent operations often require storage cells. A single such cell is charged by one signal channel and discharged by the other. Other elements required include timers and pulse generators.

The control processes can be divided into four groups. Examples of each follow:

(a) Control processes with switchover to a different mode of control. The block diagram in Figure 2 repre-

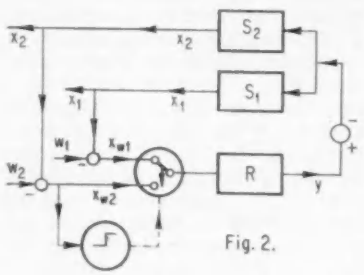


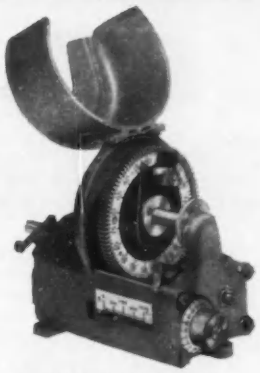
Fig. 2.

sents an electrical frequency control which switches over to current control by means of a gate when the current exceeds a given limit. The gate is triggered by the current. The excess X_{w2} of the current X_2 over its desired value W_2 is transformed into a binary signal to the gate.

(b) Cut-off circuits. Figure 3 shows the ordinary control loop, used here for keeping the liquid level constant.

The "cut-off" circuit of Figure 4, for intermittent processes, is almost identical to (b). The only difference is in the use of an intermediate relay between the float contact and the magnetic valve. The relay stores the signal from the float so that the valve does not open again when the liquid level drops. To start the cycle again,

COUNT-REGULATED CIRCUIT CONTROL WITH AUTOMATIC RECYCLING

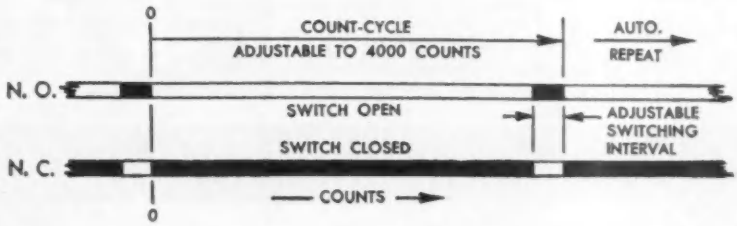


CYCLO-MONITOR
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CYCLO-MONITOR

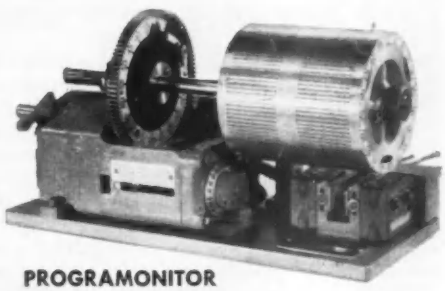
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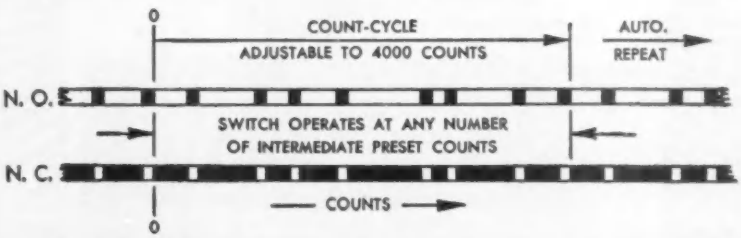


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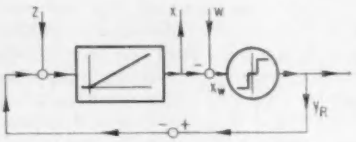
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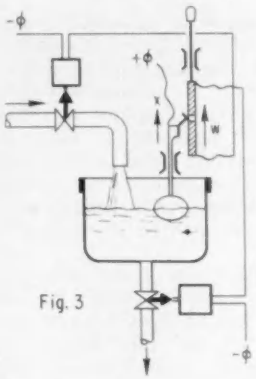


Fig. 3

the storage cell or relay must be reactivated, either manually or automatically. Either of two limiting states can result, one signifying "vessel empty", the other "vessel full".

(c) Systems with changing parameters. Some of the operations in batch processes are essentially continuous. These can cause peculiar conditions and create difficult problems. Temperature and pressure levels of a charge, for instance, are difficult to maintain when the material flows readily at the start and changes during the process to a highly viscous state. The resale is a change of the heat transfer characteristics and the time constants connected with it. Such cases often lead to control problems so difficult that they become manageable only when the setting parameters of the controls are changed during the process. The mathematical treatment of these conditions involve differential equations with variable characteristics.

(d) Systems using computers in the control circuit. There are two main uses of computers in batch processes, to influence the course of events according to given predetermined equations, and to solve the problem by systematic trials, so to speak, when the basic equations are not known. In the first application, the computer derives the output values from the inputs according to fixed, more or less complicated equations continually or stepwise.

Storage devices are the **heart** of a system producing stepwise infor-

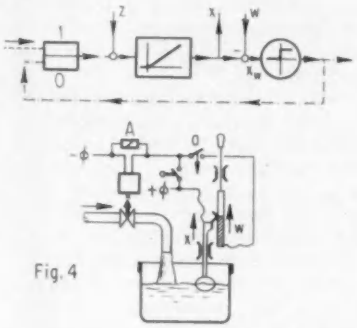


Fig. 4

mation: they make it possible to perform certain mathematical operations between the individual steps, such as finding the necessary command variable through interpolation between the individual stored values. The desired curve shape, according to which the interpolation should be performed, is also stored. It changes from step to step and the computer reads this information at each new step.

Computers can also be used to find statistical averages. In chemical batch processes the disturbance variables sometimes fluctuate between limits so far apart that the nonlinearity of the process must be taken into account. Hence the momentary set values must be changed accordingly for optimum efficiency. Calculation of these changes requires a computer.

Where the basic equations are unknown, the computer has to perform certain logical operations and draw the consequences from their results. This, too, requires storage units. The units store the effects of the preceding step and use them as the basis for the new adjustment.

An occasion for this would be fuel-consumption control for optimum operation with minimum consumption. The computer would receive the order to vary the parameters until an optimum value is reached. The mathematical definition of this optimum must of course be supplied to the computer; it might be minimum area enclosed between response curve and the horizontal line of the equilibrium condition.

Computers of this group do not influence the command variables, but change the characteristic parameters or the mode of the computer—by way of multipliers (for the parameters) or gates (for the change in mode).

The use of computers for these purposes is not very widespread as yet, but the trend is clear.

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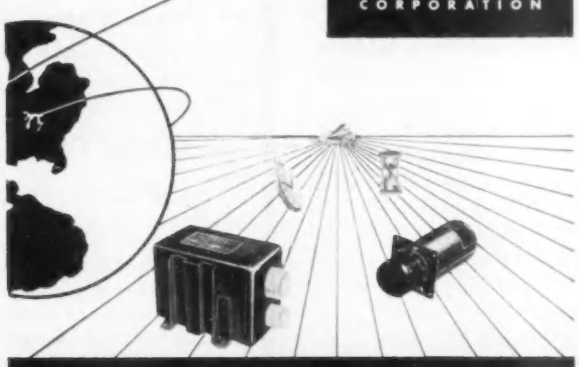
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NEW BOOKS

Data Processing Basics

HIGH-SPEED DATA PROCESSING, *C. C. Gotlieb and J. M. P. Hume, associate professors, the University of Toronto. 330 pp. Published by McGraw-Hill Book Co., Inc., New York,* 1958. $9.50

The fast pace of high-speed data processing equipment developments has left its mark on today's society. Unwittingly, the complexion of many professions has been altered considerably and the result has been a labor "scramble" in nearly every field of endeavor. An ever-increasing number of business people need to know about computers, and data processors particularly.

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Introduction to Missiles

GUIDED MISSILES—OPERATIONS, DESIGN, AND THEORY. Sponsored by the Department of the Air Force. 575 pp., 8½ x 11. Illustrated. Published by McGraw-Hill Book Co., Inc., New York, 1958. $8.

Essentially a refined, hard-cover reproduction of an Air Force training manual, this book describes and illustrates the fundamentals of the missiles field. Although written primarily for the technician-trainee, it should prove worthwhile reading for many others in this and allied fields.

Except for a few basic equations, mainly in the sections on missile physics, the treatment is nonmathematical and nowhere is too detailed.

The first three chapters (90 pages) cover the historical development of guided missiles and briefly introduce the principles of aerodynamics and propulsion as applied to the missile.

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Chapters 5, 6, 7, 9, and 11 should be of particular interest to the neophyte control engineer. In these five chapters (340 pages) the authors provide a thorough introduction to control, guidance systems and components, and telemetering.

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Credit for much of the original material must go to the staff of the Air Training Command's missile school, Lowry AFB, Colorado.

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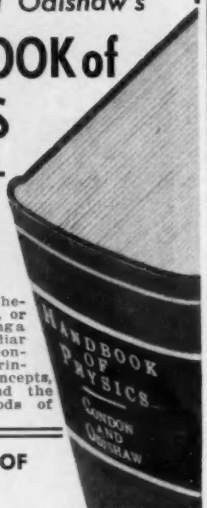
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WHAT'S AHEAD: MEETINGS

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Association Internationale Pour Le Calcal Analogue, Second International Analog Computation Meeting, Strasbourg, France Sept. 1-9

International Association for Cybernetics, Second International Congress on Cybernetics, Namur, Belgium Sept. 3-10

American Institute of Electrical Engineers, Power Industry Computer Application Conference, King Edward Hotel, Toronto, Canada Sept. 15-17

Instrument Society of America, Instrument-Automation Conference and Exhibit, Convention Hall, Philadelphia, Pa. Sept. 15-19

American Institute of Chemical Engineers, 38th National Meeting, Hotel Utah, Salt Lake City, Utah Sept. 21-24

Association of Iron & Steel Engineers, 1958 Iron & Steel Exposition and Convention, Cleveland Auditorium, Cleveland, Ohio Sept. 23-26

Institute of Radio Engineers, Seventh Annual Symposium on Industrial Electronics, Rackham Memorial Auditorium, Detroit, Mich. Sept. 24-25

OCTOBER

National Electronics Conference, sponsored by IRE and AIEE, Hotel Sherman, Chicago, Ill. Oct. 13-15

American Institute of Electrical Engineers, Machine Tool Conference, Statler Hotel, Hartford, Conn. Oct. 13-15

Society of Industrial Packaging & Material Handling Engineers, Annual Exposition, Competition and Short Course, Chicago, Ill. Oct. 14-16

National Conference on Industrial Hydraulics, sponsored by Armour Research Foundation, Hotel Sherman, Chicago, Ill. Oct. 16-17

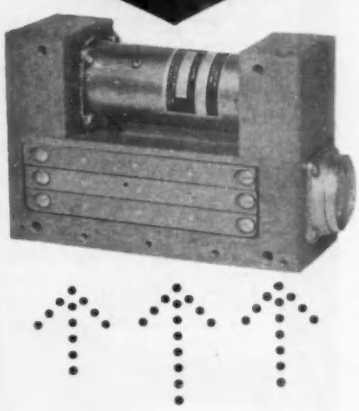
Institute of Radio Engineers, 1958 East Coast Conference on Aeronautical and Navigational Electronics, Lord Baltimore Hotel, Baltimore, Md. Oct. 27-28

American Institute of Electrical Engineers, Fall General Meeting, Pittsburgh, Pa. Oct. 27-31

Computer Applications Symposium, sponsored by Armour Research Foundation, Morrison Hotel, Chicago, Ill. Oct. 29-30

Institute of Radio Engineers, 1958 Electron Devices Meeting, Shoreham Hotel, Washington, D. C. Oct. 30-31

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The following reprints have been prepared to make important reference-type editorial material available to CONTROL ENGINEERING readers in convenient filable form. Some reprints are individual articles, while others are "packages"—several articles published over a period of time that logically supplement one another in the coverage of a specific phase of the control field. Any reprint can be obtained at the nominal cost listed below by filling in the order form and sending it, together with remittance, to Readers Service Dept. Quantity rates will be quoted on request.

Servo Design Techniques, 32 pp. A reprint of six related articles describing various electromechanical servo design techniques. Items include tachometer limiting, force-reflecting servos, calculating performance of drag-cut tachs, dual-mode servo compensation, applying packaged servo actuators, and cascading resolvers without amplifiers. 65 cents.

What's Available in Flowmeters, 24 pp. A comprehensive coverage of positive displacement, velocity, and mass flowmeters, including characteristics, applications, and typical manufacturers; plus details of a special drag disc meter. 50 cents.

Selecting and Applying Control Timers, 24 pp. A compilation of four articles including a tabular description of timer functional parts, criteria for selecting and applying control timers, a tabular listing of available timer types and their characteristics, and techniques for custom-designing controllers for time-based routines. 50 cents.

What the Control Engineer Should Know About Reliability, April 1958, 8 pp.

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Survey of Numerically-Controlled Point-to-Point Positioning Systems, 72 pp. This complete series covers 31 domestic and foreign systems. Detailed operational and performance characteristics of each system are discussed. Individual parts of series are also available as listed below. $1.25.

Survey of Numerically-Controlled Point-to-Point Positioning Systems—III, March 1958, 16 pp. Includes detailed descriptions of nine machine tool control systems. 40 cents.

Survey of Numerically-Controlled Point-to-Point Positioning Systems—II, February 1958, 24 pp. Includes detailed descriptions of ten machine tool control systems. 50 cents.

Ready Reference Data Files, 24 pp. A must for every control engineer's library. Includes the first 12 data files published in Control Engineering—a diversity of topics, from system reliability through the cost of industrial temperature-measuring systems. Each one gives a method of solving a particular problem. 50 cents.

Servo Modulators—Their Application, Characteristics, and Availability, 36 pp. A group of four integrated articles covering all phases of electromechanical, electronic, solid-state, and magnetic modulators. Typical circuit diagrams, characteristics, and applications are given for each type, plus an 84-item bibliography and tables listing commercial units. 65 cents.

The Use of Digital Computers in Science, in Business, and in Control, 112 pp. A collection of 14 articles published over a period of two years as the Digital Application Series. Prominent authorities cover the application, programming, overall system design, and commercial availability of digital computers in all phases of business, industry, and the military. $3.

Analysis Instrumentation — II — Refractometers, Infrared Analyzers, Photometric Analyzers, Colorimetry, 32 pp. This includes the second group of four articles of the Analysis Series. 60 cents.

Analysis Instrumentation — I — Nuclear Magnetic Resonance, Chromatography, Radioactivity, 32 pp. Reprint consists of first 4 articles of Analysis Instrumentation Series: a general introduction and detailed discussions of the three analysis techniques. Emphasis is on basic principles, practical tips, and the use of these techniques in automatic process control. 60 cents.

Basic Data on Process Control, 24 pp. A grouping of five articles on flow-process control, including: Basic Concepts of Feedback Control, Selecting Loops for Critical Control, Direct or Reverse Controller Actions, Modifying Valve Characteristics to fit the Process, and Using Capacitance for Accurate Level Measurement. Practical information for every process control engineer. 50 cents.



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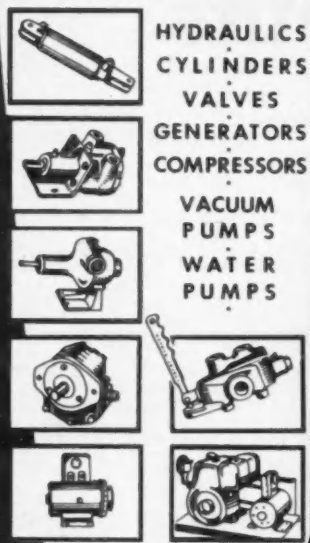
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Transistor and Thyratron Power Amplifiers, 28 pp. These three articles—one on transistors and two on thyratrons—were prompted by the increasing control application of transistors as low-power amplifiers and thyratrons as high-power amplifiers. In each case the emphasis is on practical application, circuit design, system stabilization, etc. 50 cents.

Static Switching Devices—New Tools for Industrial Control, May 1957, 28 pp. An independent consultant analyzes the complete field of industrial static-switching systems. Starting off with a review of basic switching logic, he covers circuit characteristics of the fundamental devices, commercially-available systems, actual applications, etc. 50 cents.

A Functional Analysis of Automatic Logging Systems, February 1956, 16 pp. An examination of the various techniques and equipment used in performing the eight functions in a generalized automatic logging system: transducing, scale-factor correction and linearizing, derivation of quantities, scanning, analog-to-digital conversion, programming and control, alarm, and recording or logging. 50 cents.

Automatic Machining—A View and a Preview, 24 pp. A quick look at some of the newer techniques that are being used to control machine tools. It deals primarily with recorded-information (numerical) control, discussing ways to automatically furnish machining instructions, ways to drive the tool, or workpiece, and ways to measure position and size. 50 cents.

A System Analysis Predicts Performance, June 1955, 16 pp. This rare case history shows how determining the dynamic characteristics of both the process and the control system (and considering both open to modification) can reduce cost and improve performance. 50 cents.

Digital Application Series. For those readers who would like to fill out incomplete sets of Application Series articles, the following are available as reprints:

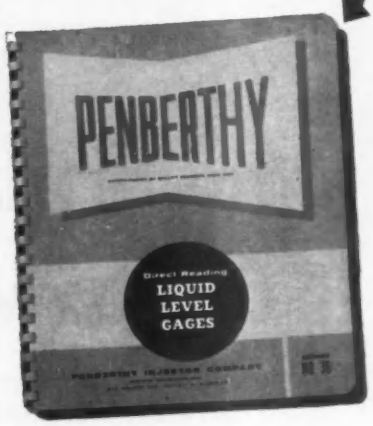
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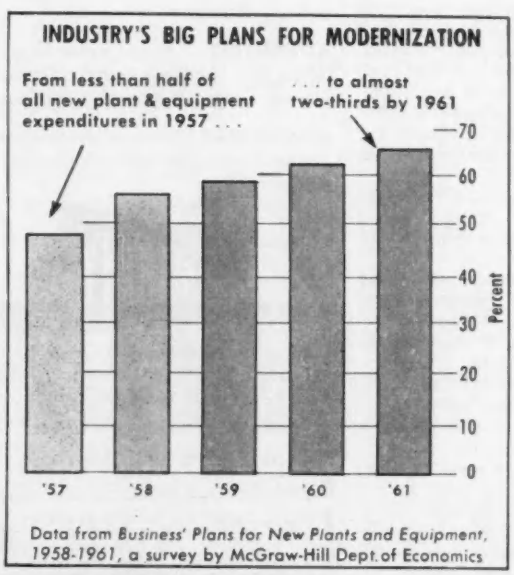
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PLAN '59

A MESSAGE TO AMERICAN INDUSTRY

Modernize Now — For Growth and Profits

The biggest challenge facing American industry today is that of thoroughly modernizing its plant and equipment. This is the test period for companies to prepare for success — or failure — in the '60s. Success depends decisively on one key policy — modernization, for growth and profits.



The problem of business recession is fading. Sales and industrial production are moving up again, slowly. Business is swinging back into its normal course. This is growth, not retreat and recession. If the recovery takes us back to the normal growth trend, industrial production will be up 15% to 20% by 1960.

But how can we get this growth in production without the plague of price inflation that has blighted our economy in recent years? And, of fateful consequence for the individual business firm, how can it keep its costs down enough to make a decent profit — something a very large share of American companies are not doing today?

This is the new challenge that confronts business as the recession is left behind.

Nature of the Challenge

The recent record on costs and productivity is not reassuring. Since 1947 wages in manufacturing have risen 68%, while output per manhour has gone up 32%. This is a dismal record for a nation that has prided itself on

gains in industrial efficiency. Clearly, if we are to avoid continuing inflation, labor must key its wage demands more closely to productivity increases. But clearly, also, we must do far better in raising output per manhour. Otherwise, industry cannot hope to offer stable prices, and still make a profit.

What, then, is the answer? It is modernization of plant and equipment, the replacement of obsolete producing facilities with new and more efficient machinery and buildings. Only in this way can industry hope to increase production, hold down costs and make a good profit showing in the years of growth that lie ahead.

Industry's Answer

The chart on the preceding page shows how American industry is buckling down to the task of modernizing its facilities over the next four years. It is planning to replace old equipment with new machines that will raise output per worker not just 2% or 3% a year, but more like the 5% annual gain in productivity that this nation achieved in the years following World War I.

Since World War II we have had to contend with shortages of capacity and materials that have held back the job of raising productivity. But today the machines and techniques are available. And industry is getting set.

A broad sample of manufacturing companies surveyed by the McGraw-Hill Department of Economics earlier this year reported these plans: **In 1958, expenditures for modernization will rise to 56% of total investment in new facilities — compared to 48% in 1957. And this emphasis will increase until by 1961, expenditures for replacement and modernization account for two-thirds of all capital spending by manufacturing companies.** In dollar terms, manufacturers will spend more on modernization in each of the four years 1958-61 than in any previous year except 1957.

Can It Be Done?

These are big plans. Can they be carried out? Is it too visionary to hope that after a decade of expansion, industry can now find the outlets for huge amounts of capital investment in the area of modernization? The answers are important to business and the nation, because on this new wave of modernization depends our hope of holding down costs and prices, and also the prosperity of the vital capital goods industries — generators of boom and bust in our economy.

To ensure that industry gets the answers, McGraw-Hill's 34 business publications are now starting a coordinated effort — the largest editorial effort in the history of our company — to find, report and publish the opportunities for modernization at a profit, in the fields we serve. These special reports will begin in late September and will run through November, with appropriate coverage for the specific needs of each field. We are proud to share with industry the responsibility for making sure that no opportunity is overlooked in the drive to modernize now for growth and profits.

This message was prepared by the McGraw-Hill Department of Economics as the first step in our company-wide effort to report on opportunities for modernization in industry. The Department is also preparing a longer report, on modernization as a national problem, for publication in October.

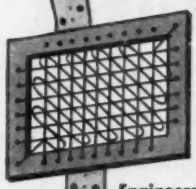
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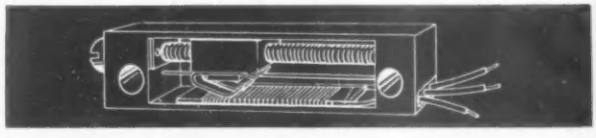
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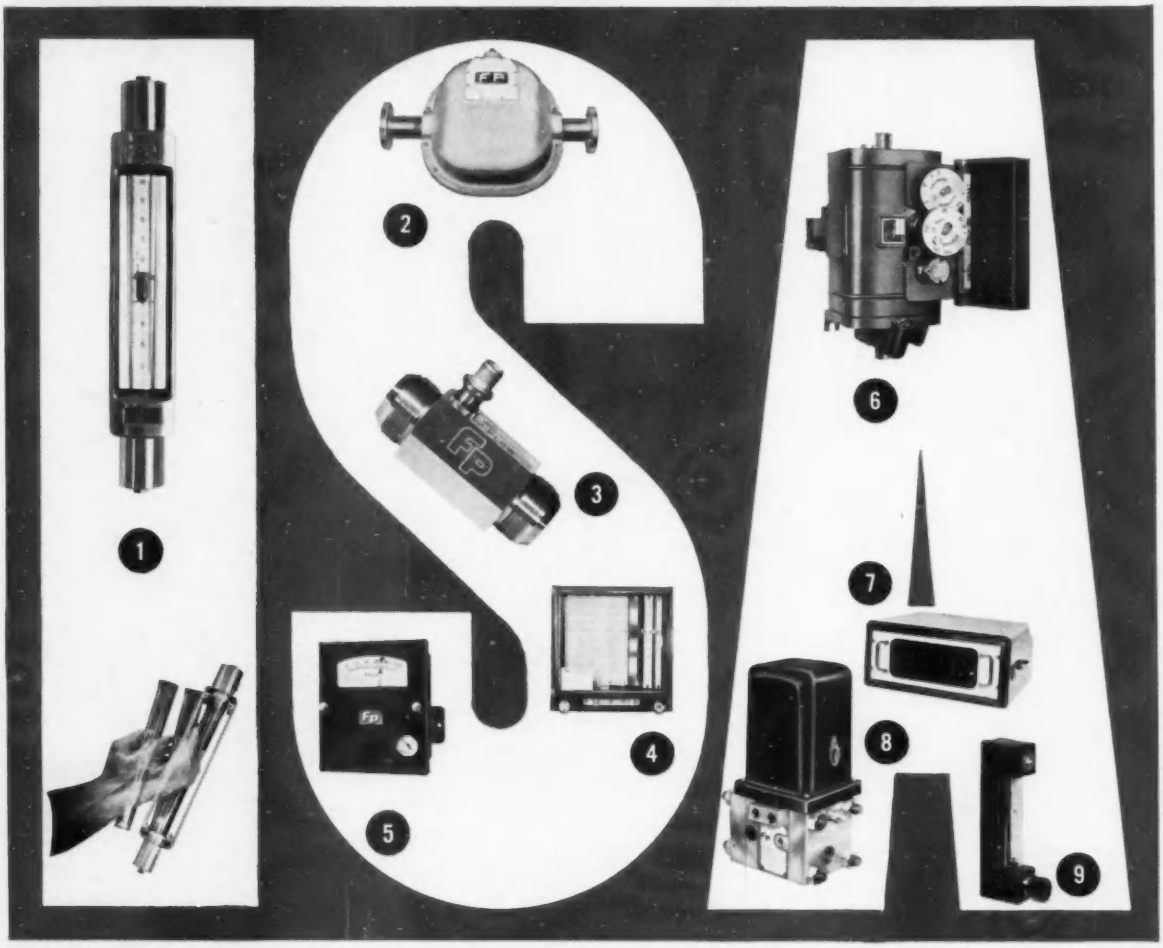
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